D2.3 Baseline Establishment for Lighthouse Cities Impact Assessment

07/04/22

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SPARCS

Deliverable administration

No & name	**D2.3** Baseline Establishment for Lighthouse Cities Impact Assessment				
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Description of the related task and the deliverable. Extract from DoA	**T2.2 Ex-Ante Lighthouse Demo Analysis and Detailed Baselining (SUITE5) M8-M30** The main aim of this task is to perform an Ex-ante evaluation of the lighthouse demos introduced in SPARCs in order to "screen the landscape" before the deployment of the actual solutions and interventions of the project, thus allowing both for the definition of a "point of reference/ baseline" for the conduction of the project assessment, along with the extraction of valuable contextual and business-oriented information to be used in business planning activities of WP7. To this end, a bottom-up approach will be adopted for the detailed survey and analysis of the lighthouse demos, through the collection and processing of relevant information for the creation of a realistic and accurate baseline with regards to the Impact Indicators (as specified in T2.1), to be used as a reference for the project impact and replication potential assessment. Moreover, the Ex-Ante analysis will investigate additional aspects in the lighthouse demos, such as available infrastructures, the targeted field of innovation, the stakeholders involved, operational and business models applied, etc. to deliver a holistic view of the current situation and provide valuable feedback to the demo WPs (WP3-WP4), as well as, to the exploitation planning activities of the project (WP7).				
Participants	SUITE5, VTT, ESP, LPZ, KONE, SIE, PIT, CIT, ADV, WSL, LSW, CEN, SEE, VERD				
Comments					

V	Date	Authors	Description
0.10	15/01/2022	Suite5	First draft of ToC
0.20	01/03/2022	Partners contributions, ESP, LPZ, CEN, LSW, PIT, CIT, WSL, SEE, VERD, SIE, KONE, VTT	Updated version with partner's contribution
0.7	15/03/2022	Suite5 and VERD	Internal review
0.9	17/03/2022	Suite5	Prepared ready for review version
0.9	24/03/2022	ULEI, FHG	Version reviewed by ULEI and FHG

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0.91	28/03/2022	Suite5	Review and changes
0.99	04/04/2022	Suite5	Final draft prepared
1	07/04/2022	VTT	Release from Project Coordinator

Dissemination level		
PU	Public	X
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About SPARCS

Sustainable energy Positive & zero cARbon CommunitieS demonstrates and validates technically and socioeconomically viable and replicable, innovative solutions for rolling out smart, integrated positive energy systems for the transition to a citizen centred zero carbon & resource efficient economy. SPARCS facilitates the participation of buildings to the energy market enabling new services and a virtual power plant concept, creating VirtualPositiveEnergy communities as energy democratic playground (positive energy districts can exchange energy with energy entities located outside the district). Seven cities will demonstrate 100+ actions turning buildings, blocks, and districts into energy prosumers. Impacts span economic growth, improved quality of life, and environmental benefits towards the EC policy framework for climate and energy, the SET plan and UN Sustainable Development goals. SPARCS co-creation brings together citizens, companies, research organizations, city planning and decision-making entities, transforming cities to carbon-free inclusive communities. Lighthouse cities Espoo (FI) and Leipzig (DE) implement large demonstrations. Fellow cities Reykjavik (IS), Maia (PT), Lviv (UA), Kifissia (EL) and Kladno (CZ) prepare replication with hands-on feasibility studies. SPARCS identifies bankable actions to accelerate market uptake, pioneers innovative, exploitable governance and business models boosting the transformation processes, joint procurement procedures and citizen engaging mechanisms in an overarching city planning instrument toward the bold City Vision 2050. SPARCS engages 30 partners from 8 EU Member States (FI, DE, PT, CY, EL, BE, CZ, IT) and 2 non-EU countries (UA, IS), representing key stakeholders within the value chain of urban challenges and smart, sustainable cities bringing together three distinct but also overlapping knowledge areas: (i) City Energy Systems, (ii) ICT and Interoperability, (iii) Business Innovation and Market Knowledge.

Partners

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LIST OF ABBREVIATIONS

Abbreviation	Full title
API	Application Programming Interface(s)
CE	Citizen Engagement
CHP	Combined Heat and Power
CIM	Common Information Model
CityGML	City Geography Mark-up Language
CRO	Common Reference Operator
DER	Distributed Energy Source(s)
DMP	Data Management Platform
DSM	Demand-side Management
DSO	Distribution System Operator
Dx.y	Deliverable x.y
DoA	Description of Action
EC	European Commission
EEA	European Energy Award
EE	Energy Efficiency
EPO	European Patent Office
EPRI	Electric Power Research Institute
EU	European Union
EV	Electric Vehicle(s)
FC	Fellow City
GA	Grant Agreement
GML	Geography Markup Language
ICT	Information and Communication Technologies
IEC	International Electrotechnical Commission
IED	Intelligent Electronic Device
IPR	Intellectual property Rights
ISO	International Organization for Standardization
JSON	JavaScript Object Notation
KPIs	Key Performance Indicator(s)
LEED	Leadership in Energy and Environmental Design
LHC	Light House City
LoD	Level Of Detail
LoRaWAN	Long Range Wide Area Network
LSW	Stadtwerke Leipzig GmbH

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LWB	Leipziger Wohnungs- und Baugesellschaft mbH
MaaS	Mobility as a Service
PAS	Publicly Available Specifications
PED	Positive Energy District(s)
PV	Photovoltaics
RES	Renewable Energy Sources
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SCIS	Smart Communities Information Systems
SDG	Sustainable Development Goal(s)
SECAP	Sustainable Energy and Climate Action Plan
SECC	Supply Equipment Communication Controller
SEE	seecon Engineers GmbH
SPARCS	Sustainable Positive and zero cARbon CommunitieS
SVF	SPARCS Visualisation Framework
TSO	Transmission System Operators
Tx.y	Task x.y
UI	User Interface
ULEI	The University of Leipzig
V2G	Vehicle-to-Grid
VPP	Virtual Power Plant
WFS	Web Feature Service
WP	Work Package
WSL	Wohnen & Service Leipzig
XML	eXtensible Markup Language

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EXECUTIVE SUMMARY

The present deliverable D2.3, with the title "Baseline Establishment for Lighthouse Cities Impact Assessment" provides a report on the activities of T2.2 "Ex-Ante Lighthouse Demo Analysis and Detailed Baselining" of WP2 "Monitoring and Impact Assessment". The main scope of D2.3 is to present the results of the ex-ante analysis of the lighthouse demos of SPARCS.

The data collected during this analysis are processed to allow for the establishment of sound and robust baselines for the different indicators involved into the SPARCS impact assessment framework. Main target is the final evaluation of the SPARCS interventions and the assessment of the impact achieved, following the implementation of the demo activities in the lighthouse cities.

To this end, D2.3 captures the current status of the lighthouse demos on all different levels, namely on city, district, macro and intervention level, allowing a "screening of the landscape", before the implementation of the actual solutions and interventions of the SPARCS project. Complementing the datasets utilized to calculate the KPIs defined on each level to build the appropriate baselines, this deliverable offers additional characteristics of the areas under consideration in the lighthouse demos, such as the available infrastructures, the citizen engagements activities and stakeholders involved and energy, mobility, and ICT foundations, in order to deliver a holistic view of the current situation, serving as valuable feedback to the demo activities.

Utilizing the captured information on this deliverable and the functionalities to be offered by the SPARCS Data Management Platform (DMP) and the SPARCS Visualization Framework (SVF), the monitoring of the project's impact on the cities' performance through visualization of appropriate KPIs will be enabled.

1 INTRODUCTION

1.1 Purpose of the document

The SPARCS project targets the accomplishment of citizens' inclusive carbon-free urban communities, by integrating technologies for energy positivity in buildings and districts, citizen engagement, city planning and governance, flexible grid management and energy storage and e-mobility as energy system elements. To accomplish this goal, several interventions will be implemented in the lighthouse cities that need to be closely monitored throughout the project's duration, in order to be able to assess the impact that will be achieved [SPARCS (2019)].

To this end, the main aim of this deliverable is to perform an Ex-ante evaluation of the lighthouse demos introduced in SPARCs in order to "screen the landscape" before the deployment of the actual solutions and interventions of the project, thus allowing both for the definition of a "point of reference/baseline" for the conduction of the project assessment, along with the extraction of valuable contextual and business-oriented information to be used in business planning activities.

To achieve this goal, a bottom-up approach is adopted for the detailed survey and analysis of the lighthouse demos, through the collection and processing of relevant information for the creation of a realistic and accurate baseline with regards to the Impact Indicators (as specified in T2.1)[SPARCS (2020b_D2.2) , that is to be used as a reference for the project impact and replication potential assessment. Moreover, the Ex-Ante analysis investigates additional aspects in the lighthouse demos, such as local infrastructure characteristics, the stakeholders involved in the activities and the status of energy, mobility, and ICT set-ups, in order to deliver a holistic view of the current situation and provide valuable feedback to the demo WPs (WP3 Espoo Demo-WP4 Leipzig Demo), as well as, to the exploitation planning activities of the project (WP7 Exploitation and Business Ecosystems).

1.2 Relations to other activities

In deliverable D2.3, the activities performed in T2.2 "Ex-Ante Lighthouse Demo Analysis and Detailed Baselining" of WP2 "Monitoring and Impact Assessment" are documented, with the main scope being to offer an overview of the results of the ex-ante analysis performed in the lighthouse demo cities of SPARCS project[**Error! Reference source not found.**].

To allow the continuous monitoring of the project's progress and the overall evaluation of the impact achieved by the interventions planned, this document has strong relations and receives input from the following SPARCS tasks and associated deliverables:

- T2.1 "Demo Evaluation, Impact Assessment and Cost-Benefit Analysis Framework and Associated Key Performance Indicators", where the framework for the holistic assessment of the project's interventions in the LHCs and FCs has been defined and documented in D2.1 and D2.2. Those KPIs and the related datasets required in order to be able to calculate them, served as an input to D2.3, to initiate the bottom-up approach utilized for the lighthouse demos data capturing, allowing the creation of a realistic and accurate baseline.

- T2.3 "Data gathering from demonstration activities for evaluation", with the main scope to develop a standard process for gathering the various types of data deriving from the demonstration activities, allowing the continuous monitoring of the project's progress and the overall evaluation of the impact achieved by these interventions. D2.4 [SPARCS (2021a_D2.4)] and D2.5[SPARCS (2021a_D2.5)] provide a comprehensive overview and a documentation report of the various components and services of the SPARCS ICT ecosystem, responsible for collecting, handling, storing and sharing the various datasets deriving from the SPARCS LHCs and FCs.

Moreover, the outcomes of the activities performed in D2.3 will be utilised as input in the following tasks (and in the associated deliverables), and work packages:

- T2.4 "Socio-economic, environmental and technological Impact Assessment"; where the activities undertaken and baselines created in this deliverable will form the basis for the accurate assessment of the impacts achieved as part of the intervention's implementation in the lighthouse cities, allowing the direct comparison of the monitoring data to be collected with the reference values captured.

1.3 Structure of the document

Addressing the main scope of D2.3, the structure of this document has been structured as follows:

- Chapter 1 serves an introduction, capturing the deliverable's purpose, its relation to other SPARCS tasks, accompanied with the deliverable's structure.
- Chapter 2 provides the methodology followed towards the definition of the SPARCS baseline values.
- Chapter 3 presents the results of the ex-ante analysis of the city of Espoo, providing initially a city overview, followed by the district, macro, and related intervention's outline.
- Similarly, chapter 4 provides the results of the ex-ante analysis of the city of Leipzig, with city, districts, macro, and virtual energy communities' characteristics being offered.
- Chapter 5 provides the document's conclusions.

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2 BASELINING METHODOLOGY

2.1 Main approach

One of the main objectives of WP2 is to assess the impact of SPARCS interventions on Lighthouse cities, in order to prove that the energy transformation of a city into a carbon neutral urban community could be socially and economically viable. The evaluation will be based on the Impact Assessment Framework presented in detail in D2.2; this framework considers both the key objectives of the LHCs as well as the planned interventions set out in the SPARCS contract [SPARCS (2020b_D2.2)].
These key objectives that are transposed into the project contract through an overall impact and eleven complementary impacts are presented below:

(i) The increased integration of renewable energy in the generation process.

(ii) An optimized excess heat management method.

(iii) The optimisation of the local energy systems in presence of distributed renewables storage, demand side management and e-mobility energy resources.

(iv) An improved energy performance of buildings and districts through human-centric building control optimization, advanced retrofitting and optimization of district-wide network operation.

(v) The reduction of GHG emissions and improvement of local air quality and urban well-being.

On the other hand, a total of 44 interventions consisting of more than 100 actions are performed in LHCs through the SPARCS project. Assessing the impact of these interventions is crucial, as it will validate the project objectives by providing important information on the progress of cities towards their sustainable transformation. In order to measure this progress, it is necessary to determine the initial state of cities in various areas, such as energy consumption, e-mobility, citizen participation, ICT technologies and the socio-economic sector. This initial recording of the ex-ante status of the cities will be used as a basis for comparison with the measurements that will take place during the monitoring phase of the project where the implementations will be completed, and relevant data and metrics will be available[SPARCS (2019)].
The overarching list of SPARCS impacts are presented below, while Table 1 correlates these impacts with the tangible targets of the LHCs.

List of Impacts:

Overall Impact: The seven SPARCs cities are committed in the common goal for achieving a sustainable, carbon neutral urban environment at the latest by 2050

Impact 1: SPARCs fosters meeting Global and EU climate mitigation and adaptation goals and national and/or local energy, air quality and climate targets, as relevant.

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Impact 2: SPARCs increases significantly the share of renewable energy, waste heat recovery, appropriate storage solutions and their integration into the energy system; and reduces greenhouse gas emissions

Impact 3: SPARCs leads the way towards wide scale roll out of Positive Energy Districts (PED)

Impact 4: SPARCs significantly improves energy efficiency, district level optimized self-consumption, and reduced curtailment by demonstrating Positive Energy Blocks, going well beyond current building regulations

Impact 5: SPARCs increases the uptake of E-mobility solutions

Impact 6: SPARCs improves air quality

Impact 7: SPARCs maximizes the replicability potential

Impact 8: SPARCs contribution to the improvement of innovation capacity and integration of new knowledge

Impact 9: SPARCs will trigger the creation of new market opportunities, strengthening the competitiveness and economic growth.

Impact 10: SPARCS will increase citizens' quality of life, health and well-being

Impact 11: SPARCs contributes to the European policies and supports the development of standards

Table 1 SPARCS Impacts and city targets

Impact	Espoo	Leipzig
Impact 1 SPARCs fosters meeting Global and EU climate mitigation and adaptation goals and national and/or local energy, air quality and climate targets, as relevant.		
	Carbon neutral by 2030	Reduce the CO_2 emission per capita to 2,5t until 2050
	Reduce emissions by 80% compared to 1990 levels by 2030	
Impact 2 SPARCs increases significantly the share of renewable energy, waste heat recovery, appropriate storage solutions and their integration into the energy system; and reduces greenhouse gas emissions		
Share of RES in year 2023	55-65%	15-40%
Use of waste heat in year 2023	30-50%	20-35%

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Impact		Espoo	Leipzig
Share of integrated systems (smart control/ VPP/ storage) in year 2023		30-60%	20-40%
CO2 reduction tonnes per year		In the **Lippulaiva** demonstration, the onsite PV together with geothermal heat pumps will reduce CO2 emissions -95% compared to business as usual	**Leipzig** demos are reducing the CO2 emissions -50-70% depending on the demonstration (**Baumwollspinnerei** and **Leipzig West**).
		All main demonstrations in **Espoo** have storage or virtual power plant solutions. The estimated suitable demand is reducing annual CO2 emissions by approximately 150 t CO2/MW.	
		Lippulaiva 2793 t/a from Regenerative Geothermal heating and cooling 210 t/a from PV installation 67 t/a from optimization of energy demand 223-350 t/a from EVs charging stations	**Baumwollspinnerei** 77,9 t/a from solar heat 388,97t/a from CHP-bio, elect237,12 t/a from CHP-bio, heat 16,92t/a from PV60 t/a from battery 0.02 t/a (per sq. metr) of GHG in total 600t/a from Optimization of energy system, 678,72tCO2eq/a
		Leppävaara 127.4 t/a from PV 300 t/a from BESS 240 t/a from Sello VPPs 7075.8 t/a from VPP Green electricity 1380 t/a from EVs charging stations	**Leipzig West** 535,08t/a from solar heat 75,6 t/a from PV

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Impact		Espoo	Leipzig
		Reduce mobility needs 596.7 t/a (estimated for 1086 people) 2443 t/a from e-car sharing (estimated for 1086 people)	**Virtual Energy Community** 413,53 t/a from Virtual power plant peer to peer exchange in total 3915,456 tCO_2/a
			Macro Level 623 t/a from e-car sharing (estimated for 320 citizens)
Impact 3 SPARCs leads the way towards wide scale roll out of Positive Energy Districts (PED)			
	Potential in Lighthouse cities: % of PEDs creation in the newly built or renovated building stock	55% by 2030 100% by 2050	42% by 2030 91% by 2050
Impact 4 SPARCs significantly improves energy efficiency, district level optimized self-consumption, and reduced curtailment by demonstrating Positive Energy Blocks, going well beyond current building regulations			
Summary of Energy efficiency improvements, and optimized self-consumption as well as reduced curtailment.		Increase in EE and reduced curtailment 28-30% Optimised self-consumption in use 100%	
Impact 5 SPARCs increases the uptake of E-mobility solutions			
		The estimated uptake of e-mobility solutions is 35-45% in the lighthouse cities	
Impact 6 SPARCs improves air quality			
Reductions of emissions to air (tCO_2/a)			
Transport		4696	773
RES substituting traditional energy production		10206	2794

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Impact		Espoo	Leipzig
Energy efficiency increase in blocks		607	600
Impact 9 SPARCs will trigger the creation of new market opportunities, strengthening the competitiveness and economic growth.			
		Investments to the smart city demonstrations in lighthouse cities	
City Total investment M€		686	507.14
Municipal funds M€		130	100
Private funds M€		353	400
EC contribution M€		6.25	7.14
Bankability	Payback time	2-9 years	2-9 years
	ROI	20-44%	20-44%
	DSCR	1,30-1,45%	1,30-1,45%
New jobs created in lighthouse cities as a result of SPARCs actions.		**Espoonlahti**: 200 new jobs	**Spinnerei**: 50 new jobs
		Leppävaara Center: 50 new jobs	**Leipzig West**: 20 new jobs
		Leppävaara/ Kera: 300 new jobs related to SPARCS	**Virtual District:** 200 new jobs

2.2 Impact assessment methodology

In order to define the Impact Assessment Framework presented in D2.2, the intended impacts outlined in project's contract, as presented in the previous subchapter, were studied thoroughly. Taking into consideration the targets each LHC have set as well as the way they will be implemented through SPARCS project, an in-depth analysis of the general impacts of the project took place.

This analysis had as an output an initial list of KPIs Table 2, that will be used going forward in order to monitor cities' progress towards achieving their goals. The analysis initially followed a top-down approach starting from cities' general targets. As a second step a case-by-case analysis on the districts' interventions was conducted by analysing the expected impact on the planned actions in an intervention level which resulted to

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additional set of KPIs that will capture the specific progress of the cities. More information about the followed methodology and the proposed KPIs can be found in D2.2.

Table 2 Initial list of KPIs

SPARCS committed Impacts based on DoA	KPIs directly derived from the DoA Impacts	Data needed to calculate the KPI
Overall	ROI	Return on Investment (%)
	Payback time	Payback time (years)
	DSCR	Debt Service Coverage Ratio (%)
Overall	Total electricity demand reduction (%)	Total Demand Electricity (MWh)
	Total heating demand reduction (%)	Total Demand Heating (MWh)
Overall Impact 1	Reduction of CO2-equivalent emissions (%)	CO_2-e calculations (Tons/year)
Overall Impact 2	Share of RES increase (%)	Total Energy Consumption
		Energy from renewable energy sources
Impact 1, Impact 6	Air quality	tHC Volatile hydrocarbons
		NOx (ug/m3)
		Small particulates (2 values: PM_{10} and $PM_{2,5}$) (μg/m3)
Impact 2	Excess heat recovery ratio	Total excess heat (MWh/a)
		Utilization of excess heat (MWh)
Impact 2	Increase of integrated systems share	Total available (RES, storage)systems (#)
		Integrated systems (#)
Impact 2	Energy storage increase	Number of equipment (#)
		Storage type (type)
		Storage capacity (MW/MWh)
Impact 3	Decrease of energy import share	Energy import MWh
		Total RES Energy Production on-site MWh

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Impact 4	Peak load (electricity) reduction	Peak demand electricity (MWh)
	Peak load (heating) reduction	Peak demand heating(MWh)
Impact 4	Onsite energy ratio OER	Energy production using RES (MWh)
		Total energy demand (MWh)
Impact 5	EV available for sharing	Total number of EV cars (#)
		EVs available for sharing (#)
Impact 5	Increase of EVs share in local transportation	Total number of vehicles in local transportation (#)
		EVs in local transportation (#)
		Bicycles in local transportation mode (#)
Impact 5	Transport behaviour	Total number of citizens (#),
		citizens going to work using a personal (non EV) vehicle (#) %,
		citizens using public transportation to go to work (#) %
		citizens going to work using a personal (EV) vehicle (#)
Impact 5	increase of EV charging points	# of smart EV charging points
		# of V2G EV charging points
		# of EV charging points
Impact 5	Utilization of charging stations	∑kWh charged
Impact 9	Job creation	# new jobs created by SPARCs
Impact 10	Increase citizens quality of life, health and well-being	Life expectancy at birth (years),
Impact 8	Annual number of new patents	Patents filed in the context of SPARCS (#/a)
Impact 11	Annual number of contributions to European Standardization Organizations	Contributions to European Standardization Organizations (#/a)

In order to cover all parts of LHC needs within the scope of SPARCS and all aspects of assessment of the impact achieved by the different interventions, several categories of monitoring perspectives were proposed in D2.2. During the process of defying the final KPIs lists for the Impact Assessment Framework and through the collaboration with

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project partners, it became clear that 8 distinctive categories of monitoring perspectives are required to be captured in a comprehensive way namely energy, economy, social, environmental, technology/ ICT, governance, mobility and citizens engagement. These categories provide a holistic understanding of the areas of application of the planned interventions. At the same time, supplementary KPIs emerged providing additional help to city's stakeholders for the selection of the targeted measurements that they should make towards urban transformation. These KPIs were also introduced in D2.2 where their descriptions and means of calculation are presented.

Analysing the SPARCS planned impacts and the city targets, allowed for the definition of this holistic impact assessment framework, that serves in this deliverable as a basis for the proper selection of the KPIs to be considered, followed by the definition of the baseline activities and the creation of accurate reference points. Additional aspects in the Lighthouse demos are also considered, offering a holistic view of the current situation of the demo sites.

2.3 Indicators, datasets and baseline

As already acknowledged, the baseline creation represents a piece of the overall monitor and impact evaluation framework, as defined in T2.1 of WP2, and the list of the KPIs defined following both a top-down technical analysis, as well as a bottom-up evaluation analysis on city, district, macro and intervention level, are shortly covered in section 2.2 and fully documented in D2.2. The effects of the project actions should be quantified utilizing those project level indicators, with baselines representing the initial situation of the project, or more precisely, to the situation before the project's interventions have been implemented. Taking that into account, IPMVP [IPMVP] (International Performance Measurement and Verification Protocol) provides a simple definition that determines the baseline period, as the period prior to the energy conservation measures and mobility actions.

Utilizing the calculation of energy savings as an example, the equation to calculate the savings is determined by comparing measured consumption or demand before and after implementation of an action, making suitable adjustments for changes in conditions, namely:

Energy Savings = (Baseline Period Energy – Reporting Period Energy) ± Adjustments

Separating the Baseline with the Reporting period, Figure 1 demonstrates the energy consumption or demand before and after the installation of the intervention, indicating both an adjusted baseline due to condition changes, as well as the savings achieved, due to the installation. Adjustments in the formula represent external factors that must be considered, to identify the same base for the linear comparison of readings between two separate periods, with the weather being a classic example of such an external factor. Other factors include occupancy, equipment and system operating parameters.

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The savings represent the difference between adjusted baseline and actual measured energy during the reporting period.

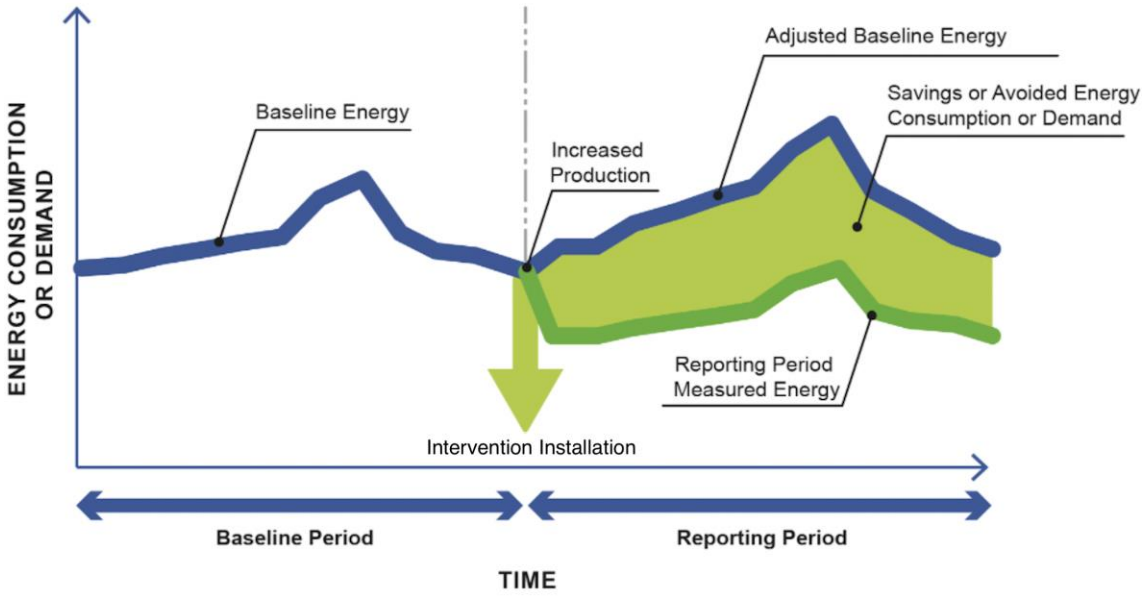

Figure 1 Energy Savings, before and after

Following this example, for the needs of the SPARCS project and taking under consideration the vast number of interventions and actions defined in the lighthouse cities, a per case definition of the baseline reference period is created, according to the available data needed to calculate the KPIs, in order to determine the "current" conditions, before the beginning of the reporting period. In each case, the baseline is considered as a "reference year" before the implementation of the actions, allowing their assessment based on the formulas defined for each KPI in D2.2. In order to calculate the adjustments of the formula, also a per case approach is needed, with the utilization of the normalization methodology as defined in D2.2 presenting a valuable tool, since it covers building and area specific factors for the calculation of normalized values and the creation of a common base for comparison.

Using Excel sheets as a support tool, partners responsible for the implementation of interventions and actions in the lighthouse cities, identified the available historical data for the calculation of the indicators, providing the baseline as a reference year value.

In the example below, with the target to be able to identify the total energy demand reduction, the electricity and the heating demand values in MWh are identified. These values, based on the historical data available for year 2020, will serve as the baseline for the assessment of impact achieved in intervention L3 in Leipzig, as soon as the implementation of the corresponding actions is ready, and the collection of the monitoring data will be possible.

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Table 3 Actual baseline data example – L3 intervention

KPIs	Data	Value	Unit	Reference Year - Comments
Total energy demand reduction	Total Demand Electricity	689	MWh	2020
	Total Demand Heating	1.282	MWh	2020

In cases that historical data is not available, with an example being actions taking place in the city of Espoo and more specifically in the Lippulaiva district, in which the shopping centre is being newly constructed, responsible partners attempted to identify and offer as baseline data values originating from similar instances. In the case of Lippulaiva, and as presented in the example below, the median values of other shopping centres are considered as baseline, for the share of RES for electricity and thermal KPIs.

Table 4 Reference baselining data example - Lippulaiva district

KPIs	Data	Value	Unit	Reference Year - Comments
Share of RES (electricity)	Total Energy consumption (electricity) (MWh) & Energy production using RES (electricity) (MWh)	Total electricity consumption: 109	kWh/gross floor area m2/year	Baseline data (reference year 2020) is a median consumption from other shopping centres, only available for total electricity consumption, not for energy production using RES (no baseline data from Lippulaiva)
Share of RES (thermal)	Total Energy consumption (thermal) (MWh) & Thermal energy production using RES (thermal) (MWh)	Total thermal energy consumption: 166	kWh/gross floor area m2/year	Baseline data (reference year 2020) is a median consumption (measured) from other shopping centres, only available for total

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				thermal energy, not for using RES (no baseline data from Lippulaiva)

Finally, for interventions that no data will be available until the implementation of the actions, the corresponding tables are filled with the abbreviation n/a (not available) to indicate this status. Such interventions include citizen engagement and business model activities, as shown in the example below, with the monitoring plan being to acquire the necessary data based on surveys and feedback from the users and citizens collected as part of co-creation and piloting activities.

Table 5 No baselining data available example - Citizen engagement

KPIs	Data	Category	Value	Unit
Number of engaged stakeholders	Number of people reached in total	Citizen engagement	n/a	# number
	Number of young people reached in total			
	Number of citizens contributed in co-created solutions			
Engagement of stakeholder	Engagement of young people: did the young people feel that they were able to contribute in the activity and feel engaged?	Citizen engagement	n/a	# number (Likert scale 1-5)
	Engagement of all citizens: did the citizens feel that they were able to contribute in the activity and feel engaged?			

Following this sequential approach, the excel files supported the city partners to identify and document in this deliverable the status of baseline data for all KPIs, that will serve as a reference point for future impact assessment calculation.

2.4 Additional holistic characteristics

Complementing this activity, a specific methodology that allows the characterization of the demo areas needs to be considered. Towards this direction, several city particularities need to be taken under account, such as the history of each city regarding sustainability issues, that indicates the involvement of local authorities and citizens in similar activities, as well as an analysis of knowledge domains, that allows efficient effort focus.

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In this regard, providing related historical information and screening of the city, their districts and the macro characteristics and knowledge domains of the lighthouse demos is considered essential, to offer a full view of the current situation, serving as valuable feedback to the demo activities as well as, to the exploitation and replication planning activities. In the table below, an example of energy related characteristics of the city of Espoo are presented, allowing to better comprehend the energy status of the city prior to the implementation of the interventions.

Table 6 Additional characteristics baselining example

Characteristics of the city of Espoo	Category	Value	Unit	Reference Year - Comments
Annual RES generation (PV, Wind, Hydro, Biomass, other)	Energy	820 $GWh_{heating}$, 1027 GWh_{elec}	GWh	2020
Annual non-RES generation (Diesel generators, Steam Turbines, Gas Turbine, other)	Energy	1162 $GWh_{heating}$, 987 GWh_{elec}	GWh	2020
Annual primary energy consumption for commercial and residential buildings	Energy	4 951 GWh	GWh	2020

In a similar way, various other categories such as mobility, social, economic, ICT and citizen engagement are captured in this deliverable, offering a holistic view of the demo areas.

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3 City of Espoo - Baselining

Espoo is the second largest city in Finland with approximately 290,000 residents[E1], and an integral part of the Helsinki capital metropolitan area. Espoo expects to reach 300,000 inhabitants by 2022 and continue growth to 400,000 residents and 180,000 jobs by 2050. One special character of Espoo is its urban structure: instead of one city centre, Espoo contains five city centres that can be seen as smaller cities within the city, providing all necessary services close to its residents.

Espoo is the most sustainable city in Europe[E2], and won the international Intelligent Community Award 2018[E3]. Espoo has been nominated a pioneer and one of the 25 cities participating in UN's SDGCity leadership programme of the UN Agenda 2030 Sustainable Development Goals. The city joined the Covenant of Mayors 2020 commitment in 2010. In February of 2018, Espoo signed the Covenant of Mayors 2030 commitment to reduce the city's greenhouse gas emissions by 40% by 2030. The City of Espoo was also the first municipality in Finland to join the national Commitment 2050 - the Society´s Commitment to Sustainable Development.

Espoo has also been recognized as being among the first movers in the Nordics in working with the 2030 Agenda[E4]. The goal is to be a top performer of sustainable city development in Europe. The overarching sustainability objective of Espoo is to reach carbon neutrality by 2030, including fossil-free district heating, and reduce its emissions by 80 % by 2030, compared to 1990.

The SPARCS goals will support Espoo's goal to be carbon neutral by 2030. The 5-year project will support Espoo in developing a common City Vision 2050 that focuses on digitalization, sustainable energy, improving air quality, e-mobility solutions and monitoring the performance of the solutions developed. The project is part of a major challenge related to enabling changes in mobility and energy use and practising a more sustainable lifestyle. In the SPARCS project, residents are at the heart of the decision-making process and the project ensures that citizens are aware of all activities.

In the Espoo Lighthouse City, the demonstrations take place in three districts that are in different phases of development and construction - from one in the planning phase (Kera), to one in a redevelopment phase (Espoonlahti district), and one already built (Leppävaara district).

City Local conditions

As previously mentioned, Espoo is the second largest city in Finland with approximately 290 000 inhabitants at the end of 2020. Espoo has been rapidly growing for decades, and the population has almost doubled since 1990, while Espoo simultaneously faces the challenge of becoming carbon-neutral in 2030. In total, Espoo has 528 km2 of land, divided between 5 city centres: Tapiola, Matinkylä-Olari, Espoonlahti, Leppävaara and Espoon keskus. All of these city centres are on central transport lines, being the city Metro or the city railway line.

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The geographical and weather characteristics of Espoo closely follow the characteristics of other Finnish cities. Espoo is quite flat with the highest point being 114m above sea level at Velskola. The average temperature ranges from a 21° C average in July to a -7°C average in February (average values are for 2021). This Nordic climate also affects the heating and cooling needs of the city, as can be seen from the large difference in Heating Degree Days (HDD) and Cooling Degree Days (CDD) of Espoo. The cold Nordic climate also affects the average sunshine hours in Espoo. Espoo averages 1890 hours of sunshine per year, heavily distributed towards the summer months.

In regard to the city's economic context, Espoo does not calculate its own GDP levels. However, the current GDP is 236.2 billion €. According to information by the Helsinki-Uusimaa Regional Council, the Finnish province of Uusimaa, which Espoo is a part of, has a 40 % share of the Finnish GDP. The current city unemployment rate is 11.7 %. This rate has gone down from the rate of 15.3 % in 2020 but is still higher than unemployment rates before COVID-19.

For air quality, EU ranks cities in terms of their average levels of fine particulate matter, otherwise known as PM2.5. With a level of 5.4 µg/m3, Espoo meets the World Health Organisation's (WHO) health-based guidelines of levels under 10 µg/m3. The value presented here is based on measurements from the Leppävaara district of Espoo, the largest city centre and busiest transport hub in the city. For noise pollution, 56 000 residents live in areas with noise levels above 55 dB according to the most resent noise level study done in 2017. This represented a fifth of the Espoo population at that time. This study is updated every five years.

Table 7 Espoo - City characteristics data

Characteristics of the city of Espoo	**Category**	**Value**	**Unit**	**Reference Year** - Comments
Population #	Social	292 796[E5]	Persons	2020
Age distribution	Social	65 402 aged 0-17, 23 529 aged 18-24, 159 826 aged 25-64, 44 039 aged 65+	Persons	2020
Life expectancy	Social	Men = 80.6, Women = 85.6	Years	2020
Population density	Social	938[E6]	Persons/km^2-land	2021
Size of the City	Physical Geography	528	km^2	2021

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Orography of the City	Physical Geography	Highest point 114m	m	No mountains
Temp (Max/Min/Average)	Physical Geography	Warmest month by average: July (31.5,10.3,20.6) Coldest month by average: February (8.4,-22.3,-6.9)[E7]	Degrees Celsius	2021 in Tapiola, Espoo measuring point
Humidity Average	Physical Geography	80[E8]	Percent	1991-2020, From Kaisaniemi, Helsinki measuring point
Average Sunshine hour per year	Physical Geography	1890[E9]	hrs/year	1991-2020, From Kumpula, Helsinki measuring point
Average Rainy days per year	Physical Geography	176[E10]	Days/year	1991-2020, Average amount of days with rain > 0.1 mm. From Kaisaniemi, Helsinki measuring point
HeatingDegreeDays	Physical Geography	3831[E11]	HDD (Heating Degree Days)	2021, Helsinki, Kaisaniemi.
CoolingDegreeDays	Physical Geography	0.42[E12]	CDD (Cooling Degree Days)	2020, Finland

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Potential Energy Resources: Yearly irradiation level	Physical Geography	980[E13]	kWh/m²	Helsinki
GDP	Economy-Financial	236.2[E14]	Billion €	2020, Finland
City unemployment rate	Economy-Financial	11.7[E15]	Percent	2021
Air pollution (eCO2, GHG, small particulates and tHC volatile hydrocarbons)[E16]	Environmental	14	µg/m³	PM_{10} (Unless otherwise specified, all air pollution data provided for year 2020 from the Leppävaara, Espoo measuring point)
	Environmental	5.4	µg/m³	$PM_{2.5}$
	Environmental	14	µg/m³	NO_2
	Environmental	6	µg/m³	NO
	Environmental	48	µg/m³	O_3 (Data from Luukki, Espoo measuring point)
	Environmental	0.2	µg/m³	SO_2 (Data from Luukki, Espoo measuring point)
	Environmental	0.2	µg/m³	BC (Data from Luukki, Espoo measuring point)
	Environmental	6	µm²/cm³	LDSA (Data from Luukki, Espoo measuring point)

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Climate Resilience Strategy	Environmental	Carbon neutral by 2030		Carbon neutral defined as = 80% emission reduction from the 1990 level, with remaining 20 % absorbed in carbon sinks or compensated
City Noise Pollution	Environmental	56 173[E17]	Number of people living in $L_{den} > 55$dB noise pollution area	2017

ICT infrastructure and services

Espoo provides a freely usable 3D City model through a Web Feature Service (WFS) interface. This 3D model aids local users in providing more efficient planning while also considering the current state of the city. In addition to buildings contained within Espoo, the model contains other properties such as parks, streets, bodies of water and vegetation. The number of users for this open data 3D city model was 327 in 2021 (data does not include internal users from different city departments).

Espoo does not provide city-wide data of new patents provided to Finnish and European patent offices. However, according to external sources, Espoo accounted for 55% of all Finnish patent applications made to the European Patent Office (EPO) in 2020[E18]. In addition, the Uusimaa province of Finland accounted for a total of 949 patent applications to the Finnish Patent and Registration Offices during the same year[E19]. However, there is no information on how many of these are provided from the City of Espoo in Uusimaa.

Table 8 Espoo - ICT and services data

Characteristics of the city of Espoo	Category	Value	Unit	Reference Year - Comments
Annual number of new patents	ICT	1042	Number	2020 (Applications provided to EPO)

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Annual number of contributions to European Standardisation Organisations	ICT	n/a	Number	No collected information available
# of digital platforms used	ICT	n/a	Number	No collected information available
Current utilization of the Espoo 3D City model	ICT	327	Number	Users, Espoo 3D open data platform (2021)

Energy and Mobility related conditions

In Finland the roles of electricity distributor and trader are differentiated. While the electricity distributor is a state legislated monopoly, the trader has a compete market-based position, meaning that electricity consumers may choose the trader, but they are bound to the local electricity distributor. Consumers' electricity prices are composed of the electricity price, taxes, and the distribution costs. Currently there are around 80 distribution system operators in Finland, most of which are municipality owned [E20]. The only distribution network operator in Espoo is Caruna Espoo Oy.
Espoo's electricity mix follows the national energy profile. In 2020, over one-half of Finland's electricity production was produced with renewable energy sources for the first time in around 50 years. [E21] Production of hydro and wind power increased considerably, while electricity produced with wood fuels went down by 13 per cent.

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In the Espoo area, the energy company Fortum is operating the district heating network that also extends to the neighbouring cities of Kauniainen and Kirkkonummi. The network has a total production capacity of over 1200 MWth.[E22]. Most of the heat demand is produced by combined heat and power (CHP) using coal or natural gas as fuel. Fortum and the city of Espoo have set the goal to abandon the use of coal in the district heating system by the year 2025. It is Espoo's most important climate action, and it is called Espoo Clean Heat. The new generation of district heating is based on replacing fossil fuels with smart and flexible solutions, e.g. by utilising waste heat, renewable electricity, geothermal energy, and bioenergy. Artificial intelligence optimises the district heating system's operations.

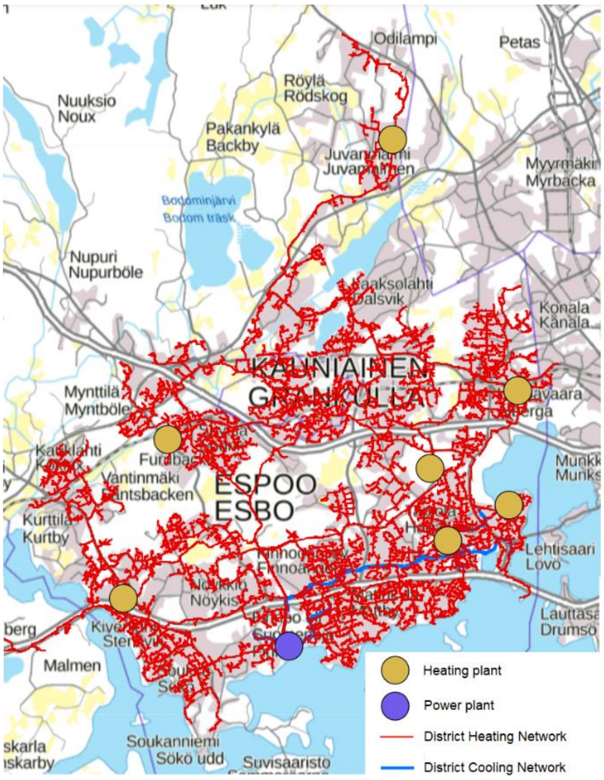

Figure 2: Fortum's District Heating Network in Espoo

Emissions per capita in Espoo were halved for the first time in 2020 compared to the baseline year 1990. The total emissions in Espoo fell in 2020 by 15 percent compared to the mission levels of 1990. The main reason for the lower emissions in 2020 is the 51 percent decline in the use of coal in the district heating system, compared to the previous year. The commissioning of the Kivenlahti bioheat plant lowered the emissions from district heating in Espoo significantly in 2020 and increased the levels of renewables in the district heating to 41 percent. The greenhouse gas emissions from transport sector decreased by 10 percent compared to the levels of the previous year, due to the changes in mobility and COVID-19. When comparing to the 1990 levels, the emissions from transport sector have increased by 1 percent, due to the growing population of Espoo.

Table 9 Espoo - Energy data

Characteristics of the city of Espoo	Category	Value	Unit	Reference Year - Comments
Annual RES generation (PV, Wind, Hydro, Biomass, other)	Energy	820 $GWh_{heating}$[E23], 1027 GWh_{elec}[E24]	$GWh_{heating}$, contains only district heating GWh_{elec}, calculated	2020

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			based on Espoo consumption and Finnish generation mix	
Annual non-RES generation (Diesel generators, Steam Turbines, Gas Turbine, other)	Energy	1162 $GWh_{heating}$[E25], 987 GWh_{elec}	$GWh_{heating}$, contains only district heating	2020
Annual primary energy consumption for commercial and residential buildings	Energy	4 951	GWh[E25]	2020, Heating consumptio n normalized
City MW installed (in regard to PV panels)	Energy	3.2	MW[E26]	2019
Annual Import/Export of energy	Energy	n/a		
Number of installations per source (RES and non-RES)	Energy	891 (PV)[E27], 4847 (Geoenergy)[E2 8]	PV installations connected to the grid in Espoo, Number of geoenergy wells in Espoo	2020
Annual Waste heat (total and utilization)	Energy	n/a		
Amount of involuntary and voluntary generation Curtailment	Energy	n/a		
Annual Open District heating utilization		n/a		

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Storage (type, #, Capacity)	Energy	n/a		
Storage energy losses	Energy	n/a		
Annual total demand Electricity	Energy	2 015	GWh	2020
Annual total demand Heating	Energy	2 140	GWh	2020, Normalized
Peak Demand	Energy	Elec = 12388	MWh/h	2020, national value
Minimum Demand	Energy	n/a		
Energy Cost (Electricity, Heating)	Energy	Elec = 0.1767 (€/kWh)[E29] Heating = 46,25 €/MWh plus yearly demand charge depending on connection	KWh, MWh	2021 (Elec), 2022 (District Heating)
Energy Efficiency annual indicator	Energy	n/a		
Flexible Load (# of connected homes, buildings, storage, etc.)	Energy	n/a		
Integrated systems share (smart control/ VPP/ storage, EV chargers)	Energy	n/a		
# of smart equipment (meters, sensors, actuators, other)	Energy	n/a		
# of EVs	Energy	Registered EVs in Espoo in 2020: 1 261 (full electric), 5 435 (e-hybrids)	#number	2020

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# of charging stations (V2G, unidirectional AND Public, Private AND car, bicycles, busses)	Energy	270 charging points (only public EV charging point data available, an estimate)	#number	2021 (Only stations in public use)
Capacity of charging stations	Energy	n/a		
EVs available for sharing	Energy	n/a		
Public lights (#, peak demand, annual demand)	Energy	Street & outdoor lights: 53600 22200 MWh Traffic lights: 2300 1400 MWh	values are estimates: number MWh elec. number MWh elec.	2020
Network Quality [E30]	Energy	SAIDI: 32 Reliability of electricity supply: 99.99 SAIFI: 0.66	min/custome r % events/ customer	2020
Electric power ancillary services availability	Energy	n/a		

Espoo city is characterized by five urban centres that, together with other areas, form a network kind of an urban structure. These centres are all hubs for mobility, services, housing, education, and workplaces, and they are connected to one another by rail (metro and commuter train connections; upcoming metro extension [2023] and new tram service [2024]), road, and bike path connections. The rapid transition towards sustainable mobility is increasingly crucial for the city's carbon neutrality 2030 target – currently, roughly one third of the city's carbon-dioxide emissions are caused by transportation. There is already 25+ electric buses utilizing the charging system in Leppävaara / Sello, roughly 270 EV charging points for public use (01/2022), and a shared city bike system with 110 stations (Table 10). The city has also piloted new ways to tackle the 'last mile'

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problem in urban mobility in recent years, including shared car systems and autonomous buses.

Table 10 Espoo - Mobility Data

Characteristics of the city of Espoo	Category	Value	Unit	Reference Year - Comments
Transport infrastructure (Km of roads for cars, bicycles,)	Transport	Roads for cars 1213Km 1195Km bicycle paths (partially joint paths with pedestrians)	Km	2014
Transport infrastructure (Public transportation lines, # of stops)	Transport	6 metro stops, 7 commuter train stops; numerous bus stops and lines	number	2022
Stock of vehicles (Cars, Motrocycles, Bikes, Buses,)	Transport	Registered vehicles in Espoo: 134. 883 (all vehicles)	number	2020
Modal Split citizens going to work using a personal (non Ev) vehicle (#) %, citizens using public transportation to go to work (#) % citizens going to work using a personal (EV) vehicle (#)	Transport	All trips: walking 26%, biking 9%, public transportation 18%, private car 46% Only work commute trips: walking 6%, biking 14%, public transportation 33%, private car 48%	%share	2018
Transportation deaths	Transport	6	#number	2020

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Citizen and stakeholder engagement

Several citizen and stakeholder engagement activities has been arranged in Espoo as part of Community engagement and Smart Business Models tasks. Covid-19 restrictions have limited the face-to-face engagement possibilities and impacted radically on people's mobility behaviour in years 2020 and 2021. Nevertheless, thousands of people have been reached via digital channels and hundreds of citizens and other stakeholders participated in SPARCS related user research and co-creation activities during 2021. During the project, we will measure the number of activities and co-creation events with citizens and other stakeholders and monitor the quality of the events. Below, are the KPIs that were defined for the engagement activities (Table 11.). We will follow the KPIs, by conducting feedback surveys after each engagement activity to evaluate the activities both qualitatively and quantitatively. Therefore, no baseline data is offered at this point of the project, but a holistic overview of the collected data will be provided at the end of the project.

The key performance indicators were formed based on quality of engagement activities - that differ from traditional KPI work which is often quantitative - to ensure high quality and democratic reach of engagement. Measuring the number of engaged stakeholders and the reach of citizens engaged are important for ensuring that the activities reach diverse groups of people and development takes place in a democratic manner. Measuring number of co-created solutions illustrates the volume of citizen-driven ideas becoming reality through co-creation. Measuring the increase of knowledge in citizens' understanding of the topic is important to indicate change in current understanding. With the KPIs we want to validate participants' possibility to impact future directions in the city in a transparent manner.

Table 11 Espoo - Citizen and stakeholder engagement data

Characteristics of the city of Espoo	Category	Value	Unit
Number of engaged stakeholders	Citizen engagement	n/a	# number of people
Engagement of stakeholder	Citizen engagement	n/a	# number (An average on a Likert scale 1-5, 1=not at all, 2=to a little extent, 3=I don't know, 4=to some extent, 5= to a great extent)
Number of co-created solutions	Citizen engagement	n/a	# number of solutions
Improving awareness of energy positive district solutions	Citizen engagement	n/a	# number (An average on Likert scale 1-5, 1=totally disagree, 5=fully agree)
Likelihood for using the developed solutions	Citizen engagement	n/a	# number (An average on Likert scale 1-5, 1=not at all,

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			2=to a little extent, 3=I don't know, 4=to some extent, 5= to a great extent)
Number of co-creation sessions for (energy positive) business models	Citizen engagement	n/a	# number of sessions
Stakeholders reached to contribute in business model / solution co-creation	Citizen engagement	n/a	# number of people
Were the mobility insights useful for the city planning authorities?	Citizen engagement	n/a	# number (An average on Likert scale 1-5, 1=not at all, 2=to a little extent, 3=I don't know, 4=to some extent, 5= to a great extent)
Number of stakeholders reached	Citizen engagement	n/a	# number of people

3.1 Espoonlahti and Lippulaiva demo site

3.1.1 District details

The Espoonlahti district is located on the south-western coast of Espoo. With 57,000 inhabitants, it is the second largest of the five Espoo city centres. The number of inhabitants is estimated to grow to 70,000 within the next 10 years, and double by 2050. Within the Espoonlahti district, the City of Espoo aims to create a special core area combining science, research, education and businesses to develop future solutions for a circular and bio economy. The area will be significant in creating new jobs, business, services as well as smart city and zero/low-carbon solutions. An example of this new development is the VTT Bioruukki piloting centre for new solutions for bio-based products and circular economy.
Espoonlahti will be a future transit hub for south-western Espoo, as it is situated along the developed metro line extension. The increased stream of passengers provides a huge potential for retail, business and residential development. E-mobility solutions and last-mile services have strong potential in the area when the subway extension is finished and running. The extensive (re)development of the Lippulaiva blocks, situated on top of a future metro station, will serve as the local centre for housing and commerce as the new Lippulaiva complex is opened in March 2022. More information on the Lippulaiva centre will be provided in the next section.

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Table 12 Espoo - Espoonlahti characteristics data

Characteristics of Espoonlahti	**Category**	**Value**	**Unit**	**Reference Year - Comments**
Future number of inhabitants (by 2050)	Social	110 000[E31]	People	-
Population	Number of inhabitants in Espoonlahti	57000[E32]	Persons	2021
Number of residential buildings	Physical Geography	25889[E33]	Buildings	2019
Population in Espoonlahti	Social	56915	persons	2021
Jobs in Espoonlahti	Social	9840	jobs	2019

The new Lippulaiva demo site will be a centre for local services: groceries, restaurants and cafés, a library, a day care centre, 8 residential blocks and underground parking facilities. Lippulaiva will be located in Espoonlahti district. The leasable area of Lippulaiva will be 44,000 square metres and gross floor area about 190,000 square metres. It will house approximately 100 retailers and services. The shopping centre will be visited by an estimated eight million customers annually. The demolition of the old shopping centre Lippulaiva was completed already in 2017. The new shopping center is under construction and will be opened in March 2022 (shopping center). The owner of Lippulaiva is Citycon Oyj. Citycon is a leading owner, developer and manager of urban grocery-anchored shopping centres in the Nordic countries.
Lippulaiva will be a large traffic hub, directly connected to public transport. The new underground metro line and station, and feeder line bus terminal, will be fully integrated. Heating and cooling demand of Lippulaiva shopping center and residential buildings is mostly covered with heat pump plant. On-site RES production includes a 4 MW regenerative ground source heat pump plant, approximately 50,000 m of bore holes and a PV system with peak power of approximately 634 kWp.

Table 13 Espoo - Lippulaiva demo data

System	Description	Value	Unit	Reference Year - Comments
Demo size	Groceries, restaurants and cafés, a library, a day care centre, 8 residential blocks	190,000	square metres	2022

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	and underground parking facilities			
Ground source heat pump plant	Power	4	MW	2022
PV panels	Peak power	634	kWp	2022
Electric battery	Power/ Capacity	1,5/1,5	MW/MWh	2022

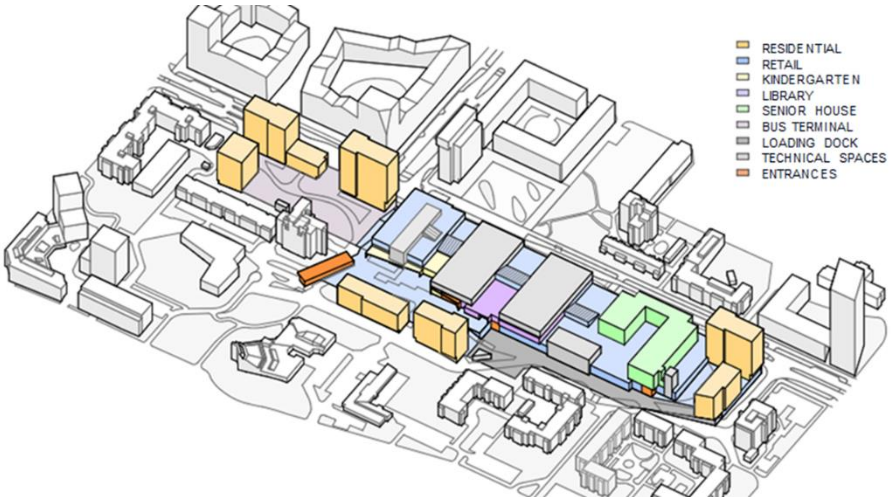

Figure 3 Lippulaiva architecture picture as it will be when ready and the main functions of different buildings in Lippulaiva

Intervention E1

Solutions for Positive Energy Blocks

Intervention E1 is about solutions for Positive Energy Blocks in Lippulaiva. The intervention includes actions about:

- NZEB & PV optimization
    - Heating and cooling in Lippulaiva are mainly covered with on-site geothermal heat pumps and utilizing excess heat. Lippulaiva will also have district heating connection and electric boiler for back-up heating system and for peak heat demand. Part of the electricity demand is produced by PV panels (roof and façade) and rest of electricity is purchased certified renewable electricity.
- Battery storage
    - The electric battery storage in Lippulaiva is used to participate in Fingrid's balancing power market to help in balancing the operation of the electricity network.
- Surrounding blocks

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- Geothermal heat pumps will also be used for heating and cooling of residential buildings of Lippulaiva.

- Predictability
  - After Lippulaiva is ready, cost comparison to base-scenario will be calculated.

Lippulaiva will be opened in March 2022. Energy metering will start in April 2022. Median consumptions are used as a baseline in the following table. Those median figures are from KTI (Finnish real estate research organisation). Baseline data is not available for other KPI's.

Table 14 Espoo - E1 intervention data

KPIs	Data	Value	Unit	Reference Year - Comments
Share of RES (electricity)	Total Energy consumption (electricity) (MWh) & Energy production using RES (electricity) (MWh)	Total electricity consumption: 109	kWh/gross floor area m2/year	Baseline data (reference year 2020) is a median consumption from other shopping centres, only available for total electricity consumption, not for using RES (no baseline data from Lippulaiva)
Share of RES (thermal)	Total Energy consumption (thermal) (MWh) & Thermal energy production using RES (thermal) (MWh)	Total thermal energy consumption: 166	kWh/gross floor area m2/year	Baseline data (reference year 2020) is a median consumption (measured) from other shopping centres, only available for total thermal energy, not for using RES (no baseline data from Lippulaiva)
Excess Heat Recovery Ratio	Total excess heat (MWh) & Utilization of excess heat (MWh)	n/a	%	No baseline data, metering will be started once Lippulaiva is open
Building energy	Total energy demand (MWh/m2)	Total: 275 Electricity:	kWh/gross floor area m2/year	Baseline data (reference year 2020) is a median

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efficiency measurement	Total Demand Electricity (MWh/m2) Total Demand Heating annual (MWh/m2) Total Demand Cooling annual (MWh/m2)	109 Thermal: 166		consumption from other shopping centres (no baseline data from Lippulaiva)
Energy Storage type	Type	n/a	type	No baseline data
Energy Storage number of equipment	Number	n/a	number	No baseline data
Energy Storage capacity	Thermal storage (MWh) & Electric battery (MW/MWh)	n/a	number	No baseline data
Total flexibility available	Total flexibility available (kW) considering EV charging points	n/a	number	No baseline data
Onsite energy ratio OER	Energy production using RES (MWh) & Total energy demand (MWh)	Energy production using RES: n/a Total energy demand: 275	kWh/gross floor area m2/year	Baseline data (reference year 2020) is a median consumption from other shopping centres (no baseline data from Lippulaiva)
Annual Mismatch Ratio (AMRx)	District Energy import (MWh) Energy production using RES (MWh) Total energy demand (MWh)	District Energy import (MWh): n/a Energy production using RES (MWh): n/a Total energy demand: 275	kWh/gross floor area m2/year	Baseline data (reference year 2020) is a median consumption from other shopping centres (no baseline data from Lippulaiva)
CO_2 emissions (Scope 2)	Total CO_2 emissions	16	kg CO_2 / net floor area m2	Baseline data (reference year 2020) is a median CO_2 emission

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				(Scope 2) from other shopping centres (no baseline data from Lippulaiva)

Intervention E2

Boosting E-mobility uptake

Boosting E-mobility in Lippulaiva and Espoonlahti district means boosting electric mobility focusing especially on mobility hubs, EV charging infrastructures and their integration to the smart grid, and mobility and accessibility through sustainable transportation options. E-mobility solutions will be developed in Lippulaiva district by offering EV parking and charging capacity as well as facilities for e-bicycle.
For the rest of the KPIs, no baselining data exist from past operation, as the new Lippulaiva concept is radically different compared to the previously demolished Lippulaiva, and the baseline is not based on any legislative or regulatory minimum.

Table 15 Espoo - E2 intervention data

KPIs	Data	Value	Unit	Reference Year - Comments
Bicycle parking	Number of parking spaces	1,400	# number	Year 2022
Charging cabinets for e-bikes	Number of cabinets	2	# number	Year 2022
EV charging stations	Number of charging spaces	134	# number	Year 2022
Demand from all EV mobility modes; impact on the grid	Demand from all EV mobility modes (considering EV Smart chargers)	n/a	MW	No baseline data, data is available once Lippulaiva is open
Ratio of peak demand from EV mobility modes to local transformer capacity	Local transformer capacity (Block)	n/a	MW	No baseline data, data is available once

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				Lippulaiva is open
Ratio of average demand from EV mobility modes to local transformer capacity	Local transformer capacity (Block)	n/a	MW	No baseline data, data is available once Lippulaiva is open
Increase of integrated EV charging units	# of EV charging stations	n/a	# number	No baseline data, data is available once Lippulaiva is open
Level of utilization of EV charging stations	Time	n/a	minutes	No baseline data, data is available once Lippulaiva is open
District EV parking/charging places (car and bicycle)	EV Car parking/charging places (#)	n/a	# number	No baseline data, data is available once Lippulaiva is open
Increase of EVs share in local transportation (%)	Total number of vehicles in local transportation (#)	n/a	# number	No baseline data, data is available once Lippulaiva is open
Utilization of the charging system	Percentage of chargers occupied	n/a	%	No baseline data

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Intervention E3

Engaging users

Piloting ways to engage and encourage citizens' energy positive ways of behaviour, developing new energy positive district solutions and improving the awareness of existing ones at Lippulaiva and Espoonlahti. Several engagement activities (interviews, surveys, information sharing, workshops and studies) have been organised by KONE, Citycon and The City of Espoo targeting schools and citizens in Espoonlahti.

No baseline data available at this point. The monitoring is done based on surveys and feedback from the users and citizens collected as part of co-creation and piloting activities as presented in the table below.

Table 16 Espoo - E3 intervention data

KPIs	Data	Value	Unit	Comments
Number of engaged stakeholders	Number of people reached in total	n/a	# number	No baseline data
	Number of young people reached in total			No baseline data
	Number of citizens contributed in co-created solutions			No baseline data
Engagement of stakeholder	Engagement of young people: did the young people feel that they were able to contribute in the activity and feel engaged?	n/a	# number (Likert scale 1-5)	No baseline data
	Engagement of all citizens: did the citizens feel that they were able to contribute in the activity and feel engaged?			No baseline data
Number of co-created solutions	Number of co-created solutions	n/a	# number	No baseline data
	Number of validated solutions			No baseline data
Improving awareness of energy positive	The activity increased the participants' knowledge about the subject matter?	n/a	# number (Likert scale 1-5)	No baseline data

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district solutions				
Likelihood for using the developed solutions	How likely would you use the solution in your daily life?	n/a	# number (Likert scale 1-5)	No baseline data

Intervention E4

Smart Business Models

Engaging (lead) users and co-creating (energy positive) business models in Lippulaiva and Espoonlahti area has been done by conducting 17 expert interviews with mobility and energy experts, and organising business model co-creation workshops with 12 mobility and real-estate stakeholders. A separate business model co-creation workshop was held with 12 end users of novel mobility concepts. SPARCS Sustainable Mobility Challenge was arranged by KONE reaching over 140 companies. 10 diverse mobility companies joined the challenge process on sustainable mobility solutions and business models. One company was selected for a pilot that will be arranged in 2022.

No baseline data is available at this point. The monitoring is done based on surveys and feedback from the stakeholders and users collected after the workshops and the co-innovation challenge as presented in the table below.

Table 17 Espoo - E4 intervention data

KPIs	Data	Value	Unit	Comments
Stakeholders reached to contribute in business model / solution co-creation	Number of stakeholders reached in total	n/a	# number	No baseline data
	Number of stakeholders contributed to co-created solutions / business model co-creation			No baseline data
Engagement of stakeholder	Did the stakeholders feel that they were able to affect and participate in the ideation of future directions?	n/a	# number (Likert scale 1-5)	No baseline data

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Number of co-creation sessions for (energy positive) business models	Number of co-creation sessions	n/a	# number	No baseline data

3.2 Leppavaara/Sello

3.2.1 District details

The Leppävaara district of Espoo is the largest and most active of the five city centres, with great connections all around the metropolitan area. It is a major transport node. The bus terminal and train station are located at the junction of the Kehä I ringroad, City Railway (expanded by 2028), and the future Jokeri Light Rail Line (operational by 2024). Now, 73,000 people live in the Leppävaara area[E34], and the number is estimated to grow to 100,000 by 2040.

In the midst of Leppävaara lies the shopping centre Sello, a key demonstration site of the SPARCS project. Sello, the second largest shopping centre in Finland measured by yearly visitors of approximately 23 million. It received the LEED environmental rating system's platinum classification for its operations in 2015. Sello's electricity needs are covered by renewable energy produced locally by PV in summer and in transitional months (750kW PV). During days with low solar irradiance virtual power plant supplies green electricity. Green energy transactions are based on GoO (Guarantees of Origin), an instrument defined by the European legislation (DIRECTIVE 2009/28/EC30) that tracks electricity from renewable energy sources and provides customers with information on the source of their energy.

The Leppävaara center also contains several innovative heating solutions linked to the local district heating grid. These include the local 40 MW Bio oil plant and 11 MW air-to-water heat pump of local energy producer and district heating operator Fortum. A decision has also been made to replicate and upscale the local heat pump solution to the Kera district, which is also a part of the Leppävaara area.

Table 18 Espoo - Leppävaara center characteristics data

Characteristics of Leppävaara	Category	Value	Unit	Reference Year - Comments
Planned new housing development (by 2030)	Physical Geography	10 000[E35]	People	-
Number of residential buildings	Physical Geography	33 691[E36]	Buildings	2019

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Population in Leppävaara	Social	72 701	persons	2021
Jobs in Leppävaara	Social	28 860	jobs	2019

Intervention E5

Solutions for Positive Energy Blocks

Sello multipurpose centre consist of five energy blocks, that will be participating in the demonstration activities. Energy blocks consist of library, shopping centre, hotel, entertainment centre and outdoor path heating. For the needs of this intervention, heat meters are installed on heating subsystems of the Sello energy blocks, allowing for energy performance modelling and heat consumption readings every 15 minutes.

Modelling of thermal energy processes helps to quantify the potential to increase energy efficiency, self-sufficiency and thermal flexibility. Sello's city blocks will be integrated with district heating system so that Sello's heating system will be able to react on the needs of local district heating company and potentially reduce the use of the fossil fuel based peak power plant(s).

Self-sufficiency of Sello city block will be evaluated through simulation of on-site production of heat with renewable energy and exporting the heat to other buildings in the city district.

To capture the impact of those actions, the total thermal electricity demand together with peak consumption of the district is considered, that based on the available historical data that is around 12 000 MWh per year for heat, with highest hourly consumption being 12 MW and 28 000 MWh electricity demand. Combined with onsite production the calculation of the baseline of the main KPIs defined for this intervention is possible.

In the table below, all KPIs defined in T2.1 are presented, accompanied with the needed datasets to calculate them and their respective baseline values. For some of the KPIs creation of baseline value was not possible due to the lack of available data.

Table 19 Espoo - E5 intervention data

KPIs	Data	Value	Unit	Reference Year - Comments
Share of RES (electicity)	Total Energy consumption (electricity)	27853	MWh	2019 All energy consumbed by Sello is produced with renewable energy. Most of the renewable electrcity is imported and rest of the
	Energy production using RES (electricity)	27853		
	Total Energy consumption (thermal)	12040		

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	Thermal energy production using RES (thermal)	12040		electrical energy is produced with local PV plant. All thermal energy is imported and is renewable
Onsite energy ratio OER	Energy production using RES (thermal)	0	MWh	2019 No on-site thermal energy production
Excess heat recovery ratio	Utilization of excess heat %	n/a	%	No baseline data
Decrease of energy import share	District Heating Energy utilized	12040	MWh	2019
Increase of district thermal energy export share	District Energy export	0	MWh	2019
	Total district Energy Production	0		
Reduction of CO2-equivalent emissions (%)	CO2-e calculations	0	tonnes/year	2019
Flexibility increase (thermal)	Change in thermal peak power demand from district heating	9.5	MWh	9.5MWh is thermal peak load of Sello from year 2019
	Potential thermal flexibility down regulation from integrated equipment	n/a	%	
	Thermal flexibility offered compared to modelled potential	n/a	MW	
#of energy subsystems monitored	¤of thermal energy subsystems monitored compared with not monitored subsystems	n/a	pcs	No baseline data

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Intervention E6

ICT for Positive energy blocks

In this intervention same energy blocks as in previous intervention will be used for demonstration activities.

Sello city block shopping block and the hotel are being developed into a micro-grid, where the integration of electricity storage with onsite electricity production (PV), power back-up generators and HVAC loads have been implemented. The microgrid is able to control flexible load and provide flexible loads to reserve markets. Sello is a forerunner on energy transition, the Sello block is the ideal testing ground for Virtual Power Plant applications that will be developed as part of this intervention.

The intervention consists of demonstrating integration of additional loads to microgrid, creating prediction models of energy markets and assets connected to microgrid, developing a digital twin of Sello multipurpose center, both visual and energy processes. Studying feasibility of connecting blockhouses with a centralized electricity storage to virtual power plant in a blockhouse environment.

To capture the impact of those actions, the total electricity demand (approx. 28 000MWh) together with flexibility potential (3.1 MW) and number of assets connected to the microgrid (125 pcs), calculation of the baseline of main KPIs defined for this intervention is possible.

In the table below, all KPIs defined in T2.1 are presented, accompanied with the needed datasets to calculate them and their respective baseline values. For some of the KPIs creation of baseline value was not possible due to the lack of available data.

Table 20 Espoo - E6 intervention data

KPIs	Data	Value	Unit	Reference Year - Comments
Total change in energy demand	Total Demand Electricity (MWh)	27853	MWh	2019
	Peak Demand (MW) electricity	6.72	MWh	2019
	Electrical energy from renewable energy sources	27853	MWh	2019. All energy consumed by Sello is produced with renewable energy. Most of the renewable electrcity is imported and rest of the electrical energy

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				is produced with local PV plant.
Annual Mismatch Ratio (AMRx)	Electrical Energy production using RES (MWh)	583.2	MWh	2019
	Onsite production using RES	583.2	MWh	2019
	District PV Generation MWh	583.2	MWh	2019
Onsite energy ratio OER	Energy production using RES (MWh)	583.2	MWh	2019
Increase of integrated systems share (smart control/ VPP/ storage)	Total available (RES, storage, HVAC, EV Charging. etc) (#)	162	pcs	2019
	Number of equipment integrated	125	pcs	2019
CO2equivalent change due to the flexibility	CO2equivalent change in t	0	tonnes	2019
Number of virtually-monitored devices	Number of heating subsystems monitored	0	pcs	2019
	Number of elevators/escalators units with virtual power demand meters monitored by VPP	0	pcs	2019
	Number of elevators/escalators units with physical power meters monitored by VPP	13	pcs	2019
Accuracy (error%) of virtual energy meter	((Total virtual energy consumption / total measured energy consumption - 1) *100%) of the tested elevators/escalators	n/a	%	No baseline data
Data availability (%)	Average availability percentage of elevator/escalator virtual power meters (total time receiving data from virtually-monitored units / total time passed * 100 %)	n/a	%	No baseline data

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Flexibility	Flexibility up offered	n/a	MWh	No baseline data
	Flexibility down offered	n/a	MWh	No baseline data
Prediction Model Accuracy	Accuracy of Generation forecasting	n/a	%	No baseline data
	GHG emission reduction from flexibility	n/a	tonnes	No baseline data
	Potential flexibility up and down from integrated equipment	3.2	MWh	2019
	Accuracy of the reserva market price, actual pricce vs. predicted price per market	n/a	%	No baseline data
	Asset flexibility prediction accuracy, prediced vs. actual	n/a	%	No baseline data
	VPP peak load reduction potential (kW) with elevator power demand forecasting data based on test setup (elevator group + controllable load)	n/a	%	No baseline data

Intervention E7

New E-mobility hub

The aim of this intervention is to develop existing mobility hub in Leppävaara, Espoo. During this project, this mobility hub begins transformation to an e-mobility hub. The future scenarios of this e-mobility hub are also simulated.

Action E7-1 aims to develop Leppävaara EV-mobility hub as a whole. Helsinki Region Transport and the City of Espoo have high targets for the electrification of transport. The Sello block will be developed into a new E-mobility hub connecting local and long-distance trains, city E-buses and a new fast E-tramline. Interoperability of charging infrastructure will be ensured to provide access for other user groups, e.g. electric service vehicles and mobile machinery. The requirements and impacts on the electrical grid will be analysed in collaboration with all relevant stakeholders.

Action E7-2 is about development of EV charging for customers of the shopping centre and commuter parking as a part of the total building power management and microgrid solutions. Optimisation of EV car charging and power management is one of the targets, with the utilisation of activity-based models for load prediction and the development of energy demand response services (V2G) being in focus, offering control strategies based on business models (Park&Charge concept). The definition of dynamic pricing models for

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electric vehicle charging, and the price of electricity depending on the flexibility resource the EV can bring, are key elements of these actions. Test would focus also to gain user experience data out of the EV charging usage for the future energy optimization purposes and to connect EV charging stations to VPP, for integrating data and services.
Action 7-3 research current and future scenarios of this e-mobility hub. This is done by simulations with different vehicles and charging strategies. Simulations will provide optimal charging strategies for commercial vehicle fleet.
In the table below, all KPIs defined are presented. Baseline values can also be found in this table. For some KPIs there are no baseline values due electrification of diesel fleet.

Table 21 Espoo - E7 intervention data

KPIs	Data	Value	Unit	Reference Year - Comments
Increase of citizens using EV modes	Total number of citizens (#)	279044 / 71628	Persons	Espoo 2018 / Leppävaara 2020
	Citizens using public transportation to go to work (#) %	48	%	Espoo and Kauniainen area 2018 (only people who live in the Helsinki Metropolitan Region)
	Citizens going to work using a personal (EV) vehicle (#) %	52	%	Espoo and Kauniainen area 2018 (only people who live in the Helsinki Metropolitan Region)
Demand from all EV mobility modes; impact on the grid	A sum of the demand from all EV mobility modes	n/a	kW	No baseline data
Peak load reduction	Peak demand (kWh)	n/a	kWh	No baseline data
Total flexibility available (kW)	Flexibility provided (KWh) Buildings/Prosumers	n/a	kWh	No baseline data
Flexibility % of normal load	Flexibility % of normal load. Buildings/Prosumers	n/a	kWh	No baseline data
Greenhouse gas emissions reduction	CO2 kg reduction based on charged electricity (EV)	n/a	CO2 kg	No baseline data

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Electric vehicle charging	Charging time / day and charging time / month.	n/a	hours	No baseline data
	Charged power / month and charged power / day.	n/a	kWh	No baseline data
	Utilization of chargers in the system after charging strategy	n/a	%	Simulated during the project
	Peak demand reduction using the charging strategy	n/a	kWh	Simulated during the project
	Number of charging strategies simulated.	n/a	pcs	Simulated during the project
Ratio of peak demand from EV mobility modes to local transformer capacity	Local transformer capacity / peak demand from all EV mobility modes	n/a	%	No baseline data
Ratio of average demand from EV mobility modes to local transformer capacity	Local transformer capacity / average demand from all EV mobility modes	n/a	%	No baseline data

Intervention E8

Engaging users

In this task, the aim is to study citizens' energy positive mobility behaviours with ethnographic research, surveys and workshops, identify lead user innovations by conducting expert and lead user studies, develop new and improve the awareness of existing positive district solutions during the daily use of Sello services. The main focus has been to experiment concepts for encouraging people to use E-mobility solutions for their daily mobility habits optimizing people flow from energy and user experience perspectives. Several engagement activities (interviews, surveys, information sharing, workshops and studies) have been arranged to develop, experiment and validate the concepts with citizens of Leppävaara. The concept development has served input for experimentation in Leppävaara and Espoonlahti and sharing insights for the development of Kera.

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No baseline data are available at this point. The monitoring is done based on surveys and feedback from the users and citizens collected as part of engagement activities as presented in the table below.

Table 22 Espoo - E8 intervention data

KPIs	Data	Value	Unit	Comments
Number of engaged stakeholders	Number of people reached in total	n/a	# number	No baseline data
	Number of citizens contributed in co-created solutions			No baseline data
Engagement of stakeholder	Engagement of all citizens: did the citizens feel that they were able to contribute in the activity and feel engaged?	n/a	# number (Likert scale 1-5)	No baseline data
Number of co-created solutions	Number of co-created solutions	n/a	# number	No baseline data
	Number of validated solutions			No baseline data
Improving awareness of energy positive district solutions	The activity increased the participants' knowledge about the subject matter?	n/a	# number (Likert scale 1-5)	No baseline data
Likelihood for using the developed solutions	How likely would you use the solution in your daily life?	n/a	# number (Likert scale 1-5)	No baseline data

Intervention E9

Smart Business Models

Engaging (lead) users and co-creating (energy positive) business models in Sello and Leppävaara area has been done by conducting 17 expert interviews with mobility and energy experts, and organising business model co-creation workshops with 12 mobility and real-estate stakeholders. A separate business model co-creation workshop was held with 12 end users of novel mobility concepts. SPARCS Sustainable Mobility Challenge was arranged by KONE reaching over 140 companies. 10 diverse mobility companies joined the challenge process on sustainable mobility solutions and business models. One company was selected for a pilot in 2022.

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No baseline data are available at this point. The monitoring is done based on surveys and feedback from the stakeholders and users collected after the workshops and the co-innovation challenge as presented on the table below.

Table 23 Espoo - E9 intervention data

KPIs	Data	Value	Unit	Comments
Stakeholders reached to contribute in business model / solution co-creation	Number of stakeholders reached in total	n/a	# number	No baseline data
	Number of stakeholders contributed to co-created solutions / business model co-creation			No baseline data
Engagement of stakeholder	Did the stakeholders feel that they were able to affect and participate in the ideation of future directions?	n/a	# number (Likert scale 1-5)	No baseline data
Number of co-creation sessions for (energy positive) business models	Number of co-creation sessions	n/a	# number	No baseline data

3.3 Kera

3.3.1 Intervention details and data available

Kera is the city planning demonstration site for Positive Energy Blocks, located in the Leppävaara district. The Kera area is a deprived industrial area developed in the 1970s and it will now be reallocated for mostly residential use. The development of Kera district is currently in city planning phase and its entire construction goes beyond the timeframe of the SPARCS project. The urban development of Kera focuses strongly on implementing advanced sustainable district energy solutions. The main objective of SPARCS is to develop and pilot new models for co-creation, energy communities and stakeholder engagement to bring residents in the new Kera district to the centre of energy ecosystem, maximizing local production and encouraging prosumer models to enhance the utilization of distributed generation.

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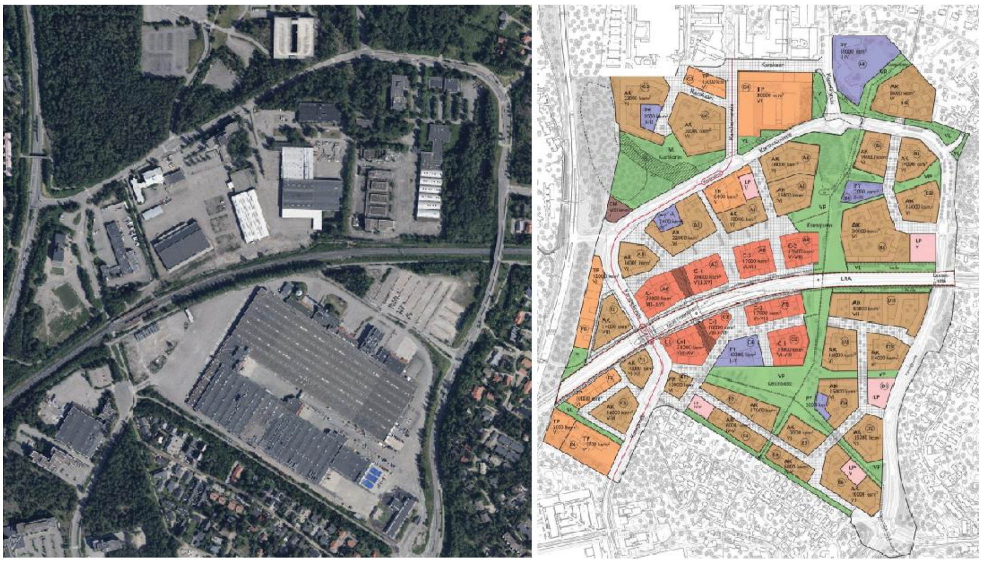

Figure 4 The Kera area in its current form (left) and a map of the detailed plan of the new residential district (right)[E37]

In its current form, the Kera district is a deprived industrial and logistical site with relatively large plot sizes. The Kera area is mainly privately owned, and the current property owners include companies like SOK (a retail company) and Nokia. The land size area of the to be developed area in Kera is about 79 hectares and consists of three detailed plans. The aim is to rebuild the area into a residential district with 14 000 citizens and 10 000 jobs. Currently there are no residential buildings within the industrial and logistical site.

Table 24 Espoo - Kera characteristics data

Characteristics of Kera	Category	Value	Unit	Comments
Land size of the to be developed area	Physical Geography	~79	ha	-
Planned gross floor area for new buildings	Physical Geography	680 000	m^2	-
Planned gross floor area for new residential buildings	Physical Geography	532 000	m^2	-
Planned gross floor area for new retail and business buildings	Physical Geography	147 000	m^2	-
Population in Kera (by 2035)	Social	14 000	persons	-
Jobs in Kera (by 2035)	Social	10 000	jobs	-

The current building stock in Kera is connected to the district heating network, but there is no centralized cooling energy production or cooling district network in the area. The

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current district heating network in Kera will be replaced with a bi-directional low-temperature district heating network. The local heating network will serve as an innovative base for the further development of local energy solutions. A new heat pump station will produce heat not only for the whole Kera district, but also for other districts in Espoo. Assuming that the electricity needed for the heat pump station will be purchased as certified green electricity, the future district heat in Kera will be carbon free.
Kera also has competitive transport links with the railway station connecting the district to downtown Helsinki and the northern parts of Espoo. The traffic planning will favour pedestrian and bicycle accesses and lanes.

Intervention E10

Solutions for Positive Energy Blocks

Intervention E10 is about solutions for Positive Energy Blocks. SPARCs demonstrates significant increase in the use of renewable energy sources and large-scale systems for Positive Energy Blocks and Districts, hence supporting a sustainable energy transition providing local and global environmental gains.
In the context of Kera this intervention (Solutions for Positive Energy Blocks) includes actions about:

- city planning for Positive Energy Blocks
- energy infrastructure solutions for Positive Energy Blocks and
- energy system planning.

The aim of this intervention is to bring forward promising technical and infrastructure solutions for Positive Energy Districts (PEDs) and to explore the benefits of using 3D city model in pursuing new opportunities and implementing PED solutions. Since the construction of the new Kera residential area goes beyond the timeframe of the SPARCS projects it is not possible to analyse or monitor the actual amount of energy produced and consumed on-site.
Currently energy is not being produced on-site in the Kera area. It has been estimated that in the future heating will account for 69% of the district's energy consumption. Electricity will account for 25% and cooling for 6%. [E38] Energy consumption is expected to rise as new buildings will be constructed over the next 10 to 20 years.

Table 25 Espoo - E10 intervention data

KPIs	Data	Value	Unit	Reference Year - Comments
Increased number of persons using Espoo 3D city model	# of people utilising Espoo 3D city model	104	users	open data WFS interface

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				users in 2018
Successful completion of the SPARCS interventions	# of goals achieved # of total goals	n/a	number	No baseline data, single value to be provided
Relation of project to city strategy	Likert to evaluate the project goals towards the city goals	n/a	number	No baseline data, single value to be provided
Number of promising technical and infrastructure solutions for PEDs		n/a	number	No baseline data, single value to be provided
Utilization of energy system planning on the new urban development planning	Likert scale to capture the utilization of energy system planning on the new urban development planning	n/a	number	No baseline data, single value to be provided
Expected on-site Energy Ratio [%] for Kera	Annual energy produced / consumed on-site	0	%	currently no on-site energy production

Intervention E11

Engaging users

Conveying research insights to city planning authorities in Kera on citizens' preferable future multimodal mobility habits, schedules and routes to optimize the people flow from energy and user experience perspectives is under evaluation, by utilizing input from user research and experimentation in Leppävaara and Espoonlahti.

The monitoring is done based on the number of authorities and other stakeholders reached in sharing events, and a survey and feedback form for the city planning authorities collected at the end of SPARCS project.

Table 26 Espoo - E11 intervention data

KPIs	Data	Value	Unit	Comments
Number of stakeholders reached	Number of stakeholders reached	n/a	# number	No baseline data

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Were the mobility insights useful for the city planning authorities?	Likert of the usefulness of the insights	n/a	# number (Likert scale 1-5)	No baseline data

Intervention E12

ICT for Positive energy blocks

Intervention E12 is about ICT for Positive Energy Blocks. The aim is to develop new potential smart energy services using e.g. 5G and blockchain technologies. The energy sector is expected to benefit from blockchain technology. The introduction of blockchain is expected to elevate demand response and energy transactions to a new level. Blockchain enables innovative platforms that help the buyer find all available renewable energy resources and make direct purchases, thus accelerating the transition to low-carbon energy and expanding access to clean energy markets for all. Distributed energy resources will play a valuable role providing grid services, such as helping to balance supply and demand in flexibility market. Blockchain technology can make it easy for distributed energy resources to participate and get compensated for delivered grid services.

Decentralized and complex energy systems require also fast communication with high capacity, bit rate, throughput, latency and energy efficiency and resilience. 5G networks are expected to provide the communication requirements for the new decentralized complex energy systems.

In the context of Kera this intervention (ICT for Positive Energy Blocks) includes actions about:

- smart infrastructure 5G
- 5G as a service enabler and
- blockchain technology as enabler.

The goal of this intervention is to identify potential 5G and blockchain solutions for Kera. This is achieved by conducting a literature review and by investigating and documenting different projects related to this topic. Also new service models for autonomous transport and e-mobility linked to the local 5G network are being investigated. As this intervention is conducted as a desktop study on possible 5G and blockchain solutions, all KPI data will be provided as a single value after this study has been completed.

Table 27 Espoo - E12 intervention data

KPIs	Data	Value	Unit	Comments
Number of potential 5G solutions identified	Number of identified solutions	n/a	Number	No baseline data, single value to be provided

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Number of potential blockchain solutions identified	Number of identified solutions	n/a	Number	No baseline data, single value to be provided

Intervention E13

E-mobility in Kera

Intervention E13 "E-mobility in Kera" aims to support the development of multimodal mobility solutions in the Kera area. The intervention both examines the replication potential of the other related interventions on e-mobility development in the other demonstration areas (E2, E7 and E18) for the future Kera area, including the consideration of their implications in the planning and design phase of an urban district, and examines the overall development of sustainable mobility and its implications for Kera, including the increasing share of shared and electric mobility globally and the related models and effects. The work in the intervention is done through desk studies and development cooperation groups, as Kera, as a future urban district, is still in the planning phase with construction work only to begin during the timeline of the SPARCS project.

Table 28 Espoo - E13 intervention data

KPI	Data	Value	Unit	Comments
Value of the developed solutions for the development of a future district	Feedback survey; Likert to capture how valuable the developed solutions for the development of future districts?	n/a	number	No baseline data, one-time evaluation
Number of e-mobility solutions introduced for replication in Kera planning phase	# of e-mobility solutions introduced	n/a	number	No baseline data, one-time evaluation
Simulated demand for charging station in Kera area		n/a	yes/no	No baseline data, one-time evaluation

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Intervention E14

New economy/ Smart governance models

Intervention E14 is about new economy / smart governance models. The main goal is to develop solutions for smart and energy efficient future living through a co-creation process between the City of Espoo and the local consortia of stakeholders. The development of the Kera area provides a valuable opportunity to test and implement energy and mobility solutions tailor-made for local needs, including the building phase of the area. Involving a wide range of stakeholders, including incumbent utilities improve the outlook of system optimization, reliability and replicability, as well as sustainable urban mobility.

For this intervention the number of citizens involved in co-creation activities will be documented. Additionally, feedback about the level of satisfactions will be gathered from participants from the different co-creation activities (such as e.g. workshops).

Table 29 Espoo - E14 intervention data

KPIs	Data	Value	Unit	Comments
Number of citizens involved in co-creation of the co-creation model	Number of citizens	n/a	Number	Will be provided once the procured model is completed
Number of stakeholders involved in co-creation of the co-creation model	Number of stakeholders	n/a	Number	Will be provided once the procured model is completed
Satisfaction of the participants in the co-creation process	Experienced satisfaction	n/a	Number (Likert scale)	Will be provided once the procured model is completed

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3.4 Macro Level

3.4.1 Macro level details

Characteristic for Urban Energy Planning in Espoo is seeking efficient means towards the carbon neutrality target. A low-emission lifestyle is supported through land use planning and assigning sites and spaces suitable for the production of renewable energy.

Regarding Integrated Energy Infrastructures, in densely populated parts Espoo is mainly served by centralised district heating system, and the City of Espoo has a strategic agreement with the local energy provider company Fortum to develop together a carbon neutral Espoo by 2030. In addition, Espoo has signed a strategic agreement with the local distribution system operator (DSO) Caruna, to facilitate further collaboration towards a carbon neutral Espoo.

The city and Fortum together are undertaking various city level energy system developments, such as gradually increasing the use of thermal demand response capacity to cover eventually all city owned building stock. The City of Espoo itself also pushes the demand for RES, as it has upgraded its own energy contracts to RES based contracts both for heat and electricity. In a long-term plan city aims for increasing E-mobility (private cars, working machines and especially public transport), autonomous transport and Mobility as a Service (MaaS) Solutions. SPARCs city level interventions towards energy positive districts in the Lighthouse City Espoo support the main objectives to develop methodologies, tools, governance and business models for smart city development.

Several VPP solutions have already been implemented in Espoo, including ones in the Sello and Lippulaiva shopping centres. From these, the Sello VPP platform is already operational, and the Lippulaiva VPP platform will begin operation after the completion of the shopping centre in 2022. Within the macro level interventions, the feasibility of this VPP platform for public buildings will be studied.

Intervention E15

Virtual Power Plant

Intervention E15 is about Virtual Power Plants (VPP's) and blockchain as a supporting technology for smart energy solutions. Action E15-1 aims to demonstrate a VPP solution for public buildings using the Espoo building stock as a pilot platform. It is expected that VPP solutions can aid public buildings in becoming active participants within the energy sector by providing flexibility to the reserve markets. This gives new ways for the buildings to play a vital role within the energy transformation, while helping us to understand the flexibility potential of different property types. As the VPP solution piloted within this action is a completely new solution for the City of Espoo, no baseline data on previously connected loads or identified business models could be identified. Instead, the city buildings will be analysed during the implementation of this action, and data will be provided when possible.

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Action E15-2 aims to prove that blockchains can be a cost-efficient and reliable solution for streamlining and automating energy prosumer and demand side management processes. As action E15-2 is closely related to actions in intervention E12, reporting is combined between the relevant actions. As this action is conducted as a desktop study on possible blockchain solutions, all KPI data will be provided as a single value after this study has been completed.

Table 30 Espoo - E15 intervention data

KPIs	Data	Value	Unit	Comments
Number of smart business models created	Number of smart business models created	n/a	Number	Will be provided at the end of the project
Loads connected to demand response	Loads connected to demand response	0	kW	None of the Espoo public building stock is currently connected to demand response
Number of blockchain solutions identified	Number of identified solutions	n/a	Number	No baseline data, single value to be provided
Number of smart business models identified in relation to blockchain solutions	Number of smart business models identified	n/a	Number	No baseline data, single value to be provided

Intervention E16

Smart heating

Intervention E16 focuses on new smart heating solutions to provide flexibility for the whole energy system. Within SPARCS, the aim is to develop the current demand-side management (DSM) solutions implemented within the local social housing company, Espoon Asunnot OY, further while assessing additional potential for energy efficiency improvements. Thus, SPARCS can show how DSM reduces the peak energy demand while reducing the use of the most carbon-intensive peak generation units. In addition, this

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intervention aims to investigate the replication potential and provide replication guidelines for smart heating solutions around Espoo.
The baseline for this intervention is calculated for 8 buildings owned by Espoon Asunnot OY. The data from these 8 buildings will then be monitored for the duration of the projects monitoring phase, thus providing an idea on how the increase of flexibility in heating will affect the energy efficiency of these buildings. These 8 buildings will serve as an example of the whole Espoon Asunnot building stock of 15 724 apartments, as monitoring the whole building portfolio was deemed to be outside of project resources and available data. Due to the availability of flexibility data from the local heating provider, a decision was made to use the years before DSM was implemented as a baseline, and collect data related to the DSM scheme during the monitoring phase. This was deemed the most realistic solution for providing a baseline for this intervention, while also providing interesting opportunities to calculate the energy consumption and CO2 emission savings between the flexibility solution and a business-as-usual case on a large scale.

Table 31 Espoo - E16 intervention data

KPIs	Data	Value	Unit	Reference Year - Comments
Heating flexibility increase as a percentage of normal load	Heat consumption per year	3 455	MWh	2019
	Heat consumption monthly average	288	MWh	2019
	Flexibility as a percentage of consumption	n/a	%	Baseline data is provided for timeframe when flexibility was not implemented
Total current and potential heat load under DSM	Total heat load under DSM	n/a	MW	No baseline data, data to be provided during monitoring phase
Current and potential emission savings	Emission savings	n/a	CO_2	No baseline data, data to be provided during monitoring phase

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Number of buildings or apartments participating in DSM scheme	Number of apartments	15 724	Apartments	2020

Intervention E17

Virtual twin

Intervention E17-1 focuses on Sello Virtual Twin predicting energy demands (electricity, district heating) and on-site electricity production from PV. This Virtual Twin visualises also the measurement values and the results in 3D building model (BIM). In addition, the intervention 17-2 focuses on studying how to use Espoo's open and public 3D CityGML as an information source to simulate solutions for energy positive blocks.

The E17-2 related KPIs does not need baseline value (new solution). For the E17-1 related KPI the baseline data is taken from literature (same kind of forecast model typical accuracy, e.g. Normalized root mean square errors). This new Sello Virtual Twin energy forecast model accuracy will be calculated using forecasted and measured hourly data (at least one year data) and compared this Sello Virtual Twin accuracy value for the value which others have typically achieved in literature.

Table 32 Espoo - E17 intervention data

KPIs	Data	Value	Unit	Reference Year - Comments
Increase of utilization of the Espoo 3D City model	Average utilization time	n/a	min	No baseline data, data to be provided during monitoring phase
Increased number of persons using Espoo 3D city model	Number of people utilising Espoo 3D city model	327	-	Users, Espoo 3D open data platform (2021)
Increase of simulations executed via the Virtual Twins concept	Number of simulations executed via the Virtual Twins concept	n/a	-	No baseline data, data to be provided during

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				monitoring phase
Number of innovative energy technologies incorporated in virtual twin for simulation purposes	Number of technologies introduced in virtual twin to improve simulations	n/a	-	No baseline data
Accuracy of building heating and electricity load forecasting (error between virtual twin and real monitored data)	Forecasted and measured hourly data of building electricity demand, space heating demand and on-site PV electricity production	0,1	-	Baseline data: Normalized root mean square errors (NRMSE) value for same kind of models in literature

Intervention E18

EV charging effects to grid

E18's title is EV charging effects to grid. It aims to map the effect of increased uptake of e-mobility on the charging demand and consequently on the grid. The main action of E18 is E18-1 which maps the optimal integration of EV charging. A variety of vehicles will be electrified during the near future, including private passenger cars, buses for public transport and commercial vehicles such as taxis, delivery trucks and maintenance vehicles. The number of electric vehicles is expected to increase constantly not only during the SPARCS project but also during many years after the project is finished. The ambition of the action is to look further into the future, up to year 2030 and beyond, and prepare for upcoming challenges. Hence, the action is heavily based on simulations utilizing the already existing data and creating estimates including all mobility modes.

Main KPIs focus on peak power and charging demand on the macro level. Additionally, the number of charging points in the Leppävaara e-hub is observed based on the data from Siemens. Finally, based on simulated scenarios the district of Kera shall get its own planning recommendations for support of EV uptake.

E18-1 Optimal integration of EV charging, taking into account all modes and types of electric vehicles, commercial as well as private, in the E-mobility nodes of Leppävaara (Sello block), Espoonlahti (Lippulaiva blocks) and Kera, managing of peak power demand and related effects from the urban planning. Analysis of future demand

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and development of smart charging strategies for different scenarios. This takes into account predictions of expected numbers of electric vehicles in each use case segment up to 2030 and beyond, the foreseen demand for power and energy and their impact to the grid. (VTT, ESP, PIT, SIE) - from the grant agreement.

Table 33 - Espoo E18 intervention data

KPIs	Data	Value	Unit	Reference Year - Comments
Increase of integrated public EV charging units	# of public EV charging stations	24	charging point	2019, data for Leppävaara hub car charging stations, provided by Siemens. Source: https://www.ensto.com/fi/yhtio/uutiset-ja-media/referenssit/ensto-sahkoauton-latausratkaisut-osaksi-kauppakeskus-sellon-kiinteistojarjestelmaa/
Peak load (electricity) reduction	Peak demand electricity (MWh)	n/a	MWh	No baseline data, data to be provided during monitoring phase through simulations based on statistical data
Demand from all EV mobility modes; impact on the grid	A sum of the demand from all EV mobility modes	n/a	MW	No baseline data, data to be provided during monitoring phase through simulations based on statistical data
Developed recommendations for future urban planning/new districts (y/n).		n/a	-	No baseline data, data to be provided during monitoring phase

Intervention E19

Sustainable lifestyle

Under this intervention, the definition and validation of solutions for optimizing urban people flow from energy and user experience perspectives are in focus. Identifying the benefits and the added value for citizen and other stakeholders in different district lifecycle phases and supporting sustainable lifestyle by providing low-emission solutions, guidance and energy advisor services to the citizens and municipal stakeholders are key elements towards this direction.

The monitoring is done based on surveys and feedback from the stakeholders and users collected after the engagement activities, workshops and the co-innovation challenge as

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presented in the table below. The Espoo level monitoring data summarises engagement data from all the Espoo demo sites and from the whole city level.

Table 34 Espoo - E19 intervention data

KPIs	Data	Value	Unit	Comments
Number of engaged stakeholders	Number of people reached in total	n/a	# number	No baseline data
	Number of citizens contributed in co-created solutions			No baseline data
	Number of other stakeholders contributed in co-created solutions			No baseline data
Engagement of all citizens and stakeholder	Engagement of all citizens and stakeholders: did the citizens/stakeholders feel that they were able to contribute in the activity and feel engaged?	n/a	# number (Likert scale 1-5)	No baseline data
Number of co-created solutions	Number of co-created solutions	n/a	# number	No baseline data
	Number of validated solutions			No baseline data
Improving awareness of energy positive district solutions	The activity increased the participants' knowledge about the subject matter?	n/a	# number (Likert scale 1-5)	No baseline data

Intervention E20

District development

Intervention E20 focuses on future replication within Espoo district development, from the viewpoint of the replication of SPARCS solutions and working methods within the Finnoo district in Espoonlahti. Within action E20-1, Espoo aims to identify requirements related to energy infrastructure, the built environment, and smart services within Finnoo. This can enable the identification of further development options and possible linkages with SPARCS solutions, while providing important knowledge for future district development on lessons learned from previous projects. As there are no KPI’s for this intervention, no table is included.

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Intervention E21

Air Quality

The air quality in the Espoo lighthouse demonstration districts is followed up in this intervention. The air quality in the Helsinki metropolitan area is measured by Helsinki Region Environmental Services (HSY) in permanent measuring points and some impermanent measuring stations, which are placed each year to a new place. In Leppävaara, where the demo site of Sello is, there is a permanent measuring station with baseline data available hourly for several years back. Near Lippulaiva there has not been any measuring point and the baseline data is taken from HSY's temporary station located in Matinkylä during year 2021. The location is similar to that of Lippulaiva, as both of them are near Länsiväylä, the big road leading west from Helsinki. The distance between Lippulaiva and Matinkylä measuring point is about 5,5km. A new measuring equipment has been acquired and is waiting to be installed in Lippulaiva to get more precise data.

Table 35 Espoo - E21 intervention data

KPIs	Data	Value	Unit	Reference Year - Comments
Air quality	PM 2.5	6,14	µg/m^3	Leppävaara 2019
	PM 10	17,08	µg/m^3	Leppävaara 2019
	NO	10,47	µg/m^3	Leppävaara 2019
	NO_2	19,62	µg/m^3	Leppävaara 2019
	PM 2.5	6,11	µg/m^3	Matinkylä 2021
	PM 10	14,93	µg/m^3	Matinkylä 2021
	NO	6,54	µg/m^3	Matinkylä 2021
	NO_2	13,70	µg/m^3	Matinkylä 2021

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Intervention E22

Co-creation for Positive Energy District

This intervention is about the co-creation for Positive Energy District development. The intervention includes actions about the co-creation for smart city development and actions about developing and disseminating smart city solutions for reaching the global Sustainable Development Goals (SDGs) of Agenda 2030.

The development of sustainable and smart districts involves many actors, developers, networks, and complex cause-and-effect relationships and new ways of co-development are needed to link all of these together. Traditional solutions and practices might not be enough for such a complex environment. The main goal of the co-creation model is to have a clear, illustrative and systematic presentation of how to develop sustainable and smart urban areas (districts, or blocks) in collaboration between the city, companies, educational institutions, research institutes, other organizations, and residents. The model not only seeks to explore how common goals for sustainable and smart solutions can be defined together with different stakeholders, but also how these solutions can be integrated into different stages of the urban planning process.

For this intervention not only the number of participants throughout the co-creation process is monitored, but also their experienced satisfaction.

Table 36 Espoo - E22 intervention data

KPIs	Data	Value	Unit	Comments
Number of citizens involved in co-creation of the co-creation model	Number of citizens	n/a	Number	Will be provided once the procured model is completed
Number of stakeholders involved in co-creation of the co-creation model	Number of stakeholders	n/a	Number	Will be provided once the procured model is completed
Satisfaction of the participants in the co-creation process	Experienced satisfaction	n/a	Number (Likert scale)	Will be provided once the procured model is completed

Intervention E23

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New economy/ Smart business models

Intervention E23 focuses on new and innovative smart business models for positive energy districts. In action E23-1, the SPARCS-project aims to collaborate with the local Smart Otaniemi innovation ecosystem. This collaboration aims to provide new replication opportunities and knowledge exchange on the SPARCS smart city solutions via co-organized networking activities and events on a local scale. The targeted outcome of this collaboration is to increase the capabilities of both the SPARCS partners and local and international stakeholders by increasing awareness on new technological developments and supporting further testing and piloting activities.

In action E23-2, SPARCS aims to leverage local and national actors, such as Business Espoo, to develop new business out of the Espoo lighthouse actions. SPARCS partners aim to enable new connections and discussions with these actors, while also promoting the SPARCS actions and solutions as a part of the Sustainable Espoo programme. Thus, these new connections can support the SPARCS partners in providing new possibilities for positive energy district development. In addition, the City of Espoo will study the city's role in supporting smart business, and related city services.

For this intervention, the number of new smart business models and additional projects will be monitored, in addition to the volume of additional funding beyond SPARCS. As these KPI's are related to the replication of solutions developed in SPARCS, no baseline data is provided.

Table 37 - Espoo E23 intervention data

KPIs	Data	Value	Unit	Comments
Number of smart business models created in Espoo	Number of business models	n/a	Number	Will be provided at the end of the project
Number of new innovative projects leveraged beyond SPARCS	Number of projects	n/a	Number	Will be provided at the end of the project
The total volume of additional funding	Volume of funding	n/a	Euro	Will be provided at the end of the project

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4 CITY OF LEIPZIG - BASELINING

Leipzig is the 8th largest city in Germany and the largest city of Saxony. It used to be the 2nd largest city of the former GDR – after East Berlin – and was an important starting point for the peaceful citizen protests that led to the fall of the GDR.

Located at the intersection of historic trade routes and due to that, home to different fairs since centuries, the city has always been marked by this particular condition. Wealthy and engaged citizens have shaped the cultural reputation of Leipzig.

Historically wealthy, Leipzig has lived periods of decline after the fall of the GDR including deindustrialisation, population shrinking, unoccupied flat rates up to 25% in the mid-1990s. Since the recent growth of population and since the beginning of the 2010s, Leipzig has been the fastest growing city in Germany, amongst others due to its popularity between students and artists.

This mixture of a history of citizen engagement from different sources has also led to citizens engaged in climate action, pressing for ambitious climate targets whilst the city is still struggling with the effects of the decline years.

The city of Leipzig joined the German Climate Alliance in 1994, setting a strict goal to reduce CO_2 emissions with the Energy and Climate protection Concept (Leipzig's SECAP) already in 2011. This has been enforced with the endorsement of the Energy and Climate Protection Program, 2014-2020, receiving its first certification (Gold Certification) in 2017 and recertified in 2021 by the European Energy Award (EEA) Benchmarking System.

In 2019, after citizen pressure, the city proclaimed climate emergency, which shall give priority to climate action and climate change adaptation in all political decisions. Based on this, in July 2020 an Emergency Program was decided including 24 short term, cross-sector emission reduction actions, related to transactions of 20 Mil Euro. Amongst other things, it states that the city administration is to become climate neutral by 2035 and the city is to become climate neutral by 2050. (The latter has been overtaken by the federal climate action law from April 2021 stating that Germany is to become climate neutral in 2045, but this is yet to be resolved by the new SECAP.)

The Emergency Programme 2021-22 links the completed Energy and Climate protection Concept 2014-2020 which would be updated for 2030 and it is currently under preparation. The latter shall include guiding medium- and long-term targets and will be passed by the City Council in June 2022.

Since 2008, Leipzig takes part in the European Energy Award programme (see above). The resulting implementation reports provide important overviews of the state of emissions and climate action in Leipzig. Leipzig has been a fellow city in the EU smart city project Triangulum, and the Interreg programmes EfficienCE and LOW-CARB. As Leipzig was a fellow partner in Triangulum, Triangulum helped to elaborate smart city- and digital transformation strategies. Especially the establishment of the Digital City Unit in April 2019 as an innovation hub within city administration was one major success of the project. EfficienCE helps to use existing data for better planning in the public transport

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system. Hereby data collected via trams are aggregated (e.g. information on speed of tram, weather conditions, energy use), analysed and used for improvements. Through the LOW-CARB EU project, the city developed a master plan for public transit in the north of Leipzig and integrate new forms of mobility from the 2030 perspective, increase the knowledge of sustainable forms of mobility through stakeholder training and implement a mobility information system as a pilot measure.

As the coordination of SPARCS is located at the Digital City Unit of the city, besides implementing technologies for energy positive buildings and districts, SPARCS Leipzig especially supports digital contributions to solving energy transition challenges.

In particular, within SPARCS several partners develop apps that aim at changing consumer behaviour, regarding heating and electricity consumption as well e-mobility charging. SPARCS provides resources to turn two districts and one virtual district into positive energy districts, and it gives important impulses to energy transition projects to various entities of the city. SPARCS Leipzig Partners prepare a data platform for orchestrating the various renewable energy assets centrally, to perform experiments with load balancing solutions, prepare studies on local energy transition challenges and prepare the replication of useful solutions in other districts of Leipzig. Additionally, the municipality targets climate just district planning, and one partner organises citizen engagement activities.

Local conditions

Leipzig, covering almost 30.000ha and inhabited by almost 600.000 people (597.493 in 2020) is located in a plain with soils rich in lignite. Due to that, it has been part of one of the three main German coal mining areas. Not only due to the energy transition, the employment structure of the region is under transition and Leipzig demonstrates a relatively low unemployment rate of 7,7%. In Leipzig, several rivers form an interior delta which is accompanied by an alluvial forest stretching through the city. Leipzig's topography is flat; it has a medium temperate continental climate. 2021 had a marked winter with a minimum of -13,6°C and an average summer with a max of +32,5°C (average temperature of 10,75°C)Leipzig references [L1]; 2020 was warmer (-3,2/+36°C, av. 12,29°C)[L2]. It has marked seasons with medium or cold winters, stormy springs and autumns, and more and more hot and dry summers. The environmental failures of the chemical industry and polluted soils under the GDR government in the area have mostly been recovered by now.

Leipzig has a per capita GDP of 39.762€/year in 2019 (current prices) which is lower than the German average per capita GDP (41.508€/year)[L3], and much lower than in many other German big cities L4].

It is difficult to account for energy balances at city level, as it is not accounted at city level. Since the liberalisation of the electricity market, consumers can choose their providers from all over Germany, and the city does not have an overview of who is consuming what types (RE/non RE) of energy on their territory. In many cases, we therefore refer to data from the public utilities, which does not cover the complete energy provision. The energy balance of the municipality only shows a fraction of the territorial consumption.

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Table 38 Leipzig city characteristics data

Characteristics of the city of Leipzig	Category	Value	Unit	Reference Year - Comments
Population #	Social	597.493	Number of people	2020
Age distribution	Social	24% under 19; 20,3% over 65; 61,6% between 20 and 65 y old	% of the population	own calculation, [L5]
Life expectancy	Social	81	years	2019[L6]
Population density	Social	2006	inhabitants/ m^2	2020, own calculation
Size of the City	Physical Geography	29.781	ha	2020
Orography of the City	Physical Geography	Flat. Highest point: 159, lowest point: 97	m over the sea	-
Temp (Max/Min/Average)	Physical Geography	36,8/ -6,2/11,3	°C	2020[L7]
Humidity Average	Physical Geography	425	mm	2020[L8]
Average Sunshine hour per year	Physical Geography	1494 is given as the norm value (but numbers are increasing in the past years; ~22+% more; 1834 h/2020, 152,8 h/per month in 2020)	h h per month	2020[L9]
Average Rainy days per year	Physical Geography	140 (min. 0,1 mm) 10 (min. 10 mm)	days	2020[L10]

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HeatingDegreeDays	Physical Geography	15 (≥30°C) 59 (≥25°C)	days	2020[L11]
CoolingDegreeDays	Physical Geography	54	days	2020[L12]
GDP per capita (current prices)	Economy-Financial	38 762	Euro	2019[L13]
City unemployment rate	Economy-Financial	7,7	percent	2020
Air pollution (eCO2, GHG, small particulates and tHC volatile hydrocarbons)	Environmental	centre PM10: 18 PM2.5: 11 NO2: 25 O3: 41	µg/m^3	2021
Climate Resilience Strategy	Environmental	SECAP 2014-2020, Emergency Programme, SECAP 2022-2030 under preparation	Action programmes	Under preparation
City Noise Pollution	Environmental	17 % daytime 18% nighttime	% of population affected by noise pollution by cars.	Noise action plan continuation, own calculation. Not including public transport, industrial noise, and air traffic, or combination
Green space	Environmental	893 (public Green space) 2 558 (city forest)	ha	2020

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		1.107 (Local recreation areas) (source 9)		

Regarding Information and Communication technology (ICT), Leipzig is developing steadily. In 2015, Leipzig was one of the three fellow cities of the EU project Triangulum. In this project, a "Smart City Implementation Plan" was developed for certain districts in the West of Leipzig.

As it became apparent that strategic city development with regards to citizen centred digitalisation was needed, the "Digital City Unit" (Referat Digitale Stadt) was installed. It is responsible for developing and implementing innovation projects, for instance in the field of urban data use in the field of mobility, energy, citizen engagement, or urban planning (e.g. projects "EfficienCE", "SPARCS", and "Connected Urban Twins"). Further fields of activity are public digitization education ("Digital Campus"), safe and unified digital municipal identities (project "ID Ideal"). One of the projects also includes installing more, and connecting existing open WLANs, facilitating the use of digital applications and sensor integration.

Within these projects, many different actors cooperate for the sake of citizen centred digitization, including various city units, different municipalities, research and science institutions, private enterprises, citizens, or public utilities.

The city of Leipzig is developing its own geodata infrastructure towards an urban data platform on which municipal data from various sources shall be connected within the municipality, to make specific information mineable. In the future it is envisioned to allow for also incorporating citizen data. Additionally, the city is active in the project "Connected Urban Twins" together with the cities Munich and Hamburg. This project is supported by the federal government, and until the end of 2025 it develops cases where urban planning can be improved by using digital twins.

Table 39 Leipzig - ICT and services data

Characteristics of the city of Leipzig	**Category**	**Value**	**Unit**	Reference Year - Comments
Annual number of new patents	ICT	n/a		No baseline data
Annual number of contributions to European Standardisation Organisations	ICT	n/a		No baseline data
# of digital platforms used	ICT	n/a		No baseline data

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number of use cases of the Leipzig 3D City model	ICT	8	number	2021
Number of digital Twin application cases	ICT	n/a	Number	No baseline data

Energy and Mobility related conditions

As mentioned, the City of Leipzig is located in a lignite area. Consequentially, a large share of its electricity and heat come from coal fired powerplants, such as the Lippendorf power plant. Leipzig possesses municipal utilities, "Leipziger Stadtwerke" (LSW), providing electricity and heat. Whereas some districts get heat from the distance district heating network (connection is mandatory), other districts are not connected and have various heat sources. In the field of electricity, since the liberalisation of the electricity market in 1998 electricity is traded all over Germany and each consumer can choose their supplier themselves.

After the declaration of climate emergency in 2020, the Climate emergency action programme defines among other things that Leipzig shall have a climate neutral energy and heat supply by 2040 and administration (including city owned buildings) shall be renewable in 2035. Currently, a plan for developing renewable heat supply for the city is under preparation and will be completed by the end of 2023. There are several projects to increase the share of RES produced within city boundaries. For instance, as part of its SPARCS activities the SPARCS partner Leipziger Stadtwerke is building a large scale solar thermal plant. Though there are projects to increase the number of PV installations in the city, renewable extension is currently proceeding slowly. The space within the city boundaries is limited and the fast growth of the city requires areas for housing and infrastructure projects; and the current German legislation makes larger private initiatives difficult to realise. This is hoped to change with the new government. Nonetheless, to incentivise small scale private action the city is preparing to issue a supporting program for the construction of PV installations on roofs.

Network stability indicators are not given at municipal level; overall, both the German SAIDI and SAIFI are low in European comparison.

Table 40 Leipzig - Energy data

Characteristics of the city of Leipzig	Category	Value	Unit	Reference Year - Comments
Annual RES generation (PV, Wind, Hydro, Biomass, other)	Energy	157,3 112,3	GWh Electricity GWh Heat	2018

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			From renewable sources in 2018[L14]	
Annual non-RES generation (Diesel generators, Steam Turbines, Gas Turbine, other)	Energy	2.146,8 (Difference to total Demand)	GWh[L15] 2018	2018
Annual primary energy consumption for commercial and residential buildings	Energy	2128	GWh 2018[L16] (only excluding municipal buildings, which account for 2% of the municipal energy consumption)	2018
City MW produced energy (produced via PV panels)	Energy	79,5 [L17]	MWpeak[L18]	2020
Annual Import/Export of energy	Energy	5720 2152	GWh heat from imports (sum) GWh electricity from imports (sum) [L19]	2018
Number of installations per source (RES and non-RES) Alternative: Renewable energy production	Energy	n/a 2.752 solar collectors 18 wind turbines 157,3 112,3	2018: For grid of Netz Leipzig: RES: 1123, non-RES (only CHP): 184 GWh electricity GWh heat	2018 2020[L20] 2022[L21] 2018[L22]

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Annual Waste heat (total and utilization)	Energy	None yet "environmental heat" (?): 45,8 0,4% of total consumption	GWh heat[L23] [L24]	2018
Amount of involuntary and voluntary generation Curtailment	Energy	0	[L25]	2018 because of grid restrictions for grids of Netz Leipzig.
RES penetration The percentage of RES energy generation as part of the overall energy generation	Energy	6,8 2,0%	% of electricity consumption % of heat consumption [L26]	2018
Storage (type, #, Capacity)	Energy	Electricity storages: 625 16,66 MW	Type, Number, MW Maximal decharging capacity	2020[L27]
Storage energy losses	Energy	n/a	MW	No baseline data
Annual total demand Electricity	Energy	2.304,1	GWhL28]	2018
Annual total demand Heating	Energy	5.491,9	GWh[L29]	2018
Peak Demand	Energy	194	MW 2018 For electrical grid of Netz Leipzig[L30]	2018

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Minimum Demand	Energy	87	MW 2018 For electrical grid of Netz Leipzig[L31]	2018
Energy Cost (Electricity, Heating)	Energy	32,62 About 6,41	ct/kwh electricity for private households ct/kWh for Gas for private households.[L32]	2021 (Other heating materials must be in the same range, otherwise they wouldn't be competitive on the market. Besides that, there is heating with coal, waste heat from different sources via district heating, oil, wood chips, solar thermal heat, ambient heat pumps, amongst others.[L33]
Flexible Load (# of connected homes, buildings, storage, etc.)	Energy		none	
Integrated systems share (smart control/ VPP/ storage, EV chargers)	Energy	0	%	2018
# of smart equipment (meters, sensors, actuators, other)	Energy		n/a	

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# of EVs	Energy	1450	number[L34]	2020
# of charging stations (V2G, unidirectional AND Public, Private AND car, bicycles, busses)	Energy	369	number[L35]	2020 (only cars without bikes & buses)
Capacity of charging stations	Energy	6.804 kW	kW[L36]	2020
Public lights (#, peak demand, annual demand)	Energy	n/a		
Network Quality (SAIDI, SAIFI)	Energy	Saidi: approximately the area of Saxony: 11,3 Min; Germany: 10,7 Min[L37]	More information about German network stability data: [L38]	2020

Leipzig forms a metropolitan area with Halle; and is within reach of Dresden and Berlin. In the field of mobility, Leipzig is located on an important axis connecting Munich and Berlin, providing both a motorway connection as well as a fast train connection. It is home to the largest European train station, which is nowadays not used to the fullest. The focus of Leipzig's train connections are mostly regional and national connections.

Regarding public transport, there are several regional small train companies, an S-Bahn (rapid transit urban and interurban railway) and a city-wide tram and bus system. There are bikes and scooters for rental, there are taxies, a company offering shared taxi rides, and various car rental and sharing operators.

There are different ways to count the modal share: considering the share of trips, or of kilometres travelled; considering only traffic from within the city, or including also traffic from abroad. Considering the most comprehensive indicator, the modal share of the kilometres travelled of all traffic within Leipzig (from both within and from abroad), 4,3% of the km travelled in Leipzig are done on foot, 10,5% on bike, 61,6% by motorised transport, and 23,5% by public transit (see figure 5).

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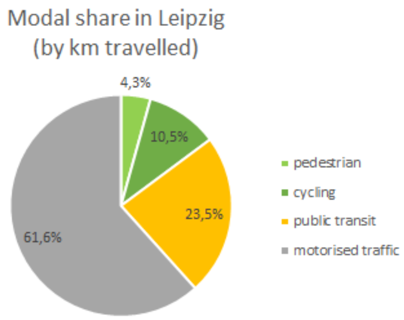

Figure 5 Modal share in Leipzig

People in Leipzig travel more (21,6km) than in Dresden (18,7km) or Berlin (20,4km) and this is unfortunately done by a higher share of motorised transport (Dresden: 57,7%, Berlin: 41,2%,)[L39]

There are 1799 km of road, 526,2 km of paths dedicated bikes (of differing quality), and 215 km of municipal tram rail (excluding S-Bahn) [L40]. 780 of 1000 households use a car (690 privately owned, 90 company cars). This is less than in other regional capitals (Halle: 820 / Dresden: 870), but more than Berlin (680) [L41].

There were 11 925 traffic accidents in 2020, in which 1735 people got hurt and in which 14 died. Whilst the number of accidents and injured is decreasing over the past years, the number of fatalities is stagnating. Motorised transport is responsible for 94,6% of the accidents. Whilst the percentage of bike accidents have been about 10,2%, they are responsible for less than half of them (for 4,6% of all accidents) [L42].

A strategic mobility plan has been elaborated in 2018. The city council opted for a "sustainability scenario" and set the following modal split goals for 2025: 30% pedestrian traffic, 20% bike traffic, 25% public transit, 25% motorised individual traffic[L43].

Table 41 Lepzig - Mobility data

Characteristics of the city of Leipzig	**Category**	**Value**	**Unit**	Reference Year - Comments
Transport infrastructure (Km of roads for cars, bicycles,)	Transport	1.799 526,2 215	km roads (for cars) km bike ways[L44] km (tram rails, excluding S-Bahn rails[L45]	2020
Urban **trips** done by active transport (bike, foot)	Transport	46% 27,3% on foot	% of trips within LeipzigL46]	2018

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		18,7% on bike		
Transport infrastructure (Public transportation lines, # of stops)	Transport	13 46	Lines (tram) Lines (bus) [L47]	2020
Vehicle stock (Cars, Motrocycles, Bikes, Buses, ...)	Transport	268.059 - thereof 23.2677 - thereof 14.785 - thereof 1450 75% of inhab. (ergo a stock of more than 450.000 bikes, bc. Some have more than one) 276 158	Motor vehicles Cars motorcycles[L48] Electric vehicles Have a bike[L49] bikes trams busses[L50]	2020
Modal Split citizens going to work using a personal (non Ev) vehicle (#) %,	Transport	4,3 % pedestrian 10,5% cycling 23,5% public transit 61,6% motorised traffic 40 % car	Percent of km travelled Percent of people going to work using this traffic mode[L51]	2018

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SPARCS

citizens using public transportation to go to work (#) % citizens going to work using a personal (EV) vehicle (#)		24 % public transport Considering the ratio of EVs and MVs, and sharing EVs, it's close to zero.		
People hurt in traffic	Transport	1735	People[L52]	2020
Collision between active and motorised transport (hurt)	Transport	Not available	number[L53]	2020
Transportation deaths/ traffic deaths	Transport	14	people[L54]	2020
Mobility plan	Transport	Foot: 30 Bike: 20 Public: 25 Motorized: 25	Percent modal split goals for 2025 (from 2018)[L55][i]	2018

4.1 Baumwollspinnerei

4.1.1 District details

The premises of the Baumwollspinnerei (former cotton mill) are protected as heritage buildings and were originally constructed in 1884. The buildings are mainly built of brick and partially renovated. Nowadays, the site houses a diverse setup of facilities combining living and working in a historical environment. Within this cosmos, the SPARCS-Activities are concentrated on the two central buildings Hall 14 and Hall 18. These two buildings claim together a demand of appr. 689 MWh electricity and appr. 1.282 MWh heat in 2020. The present renewable energy source consists of a CHP-Plant with a power of 50kWel contributing nearly 301 MWh electricity in the same year. Another CHP-Plant with an additional power-level of 100kWel is implemented this year, outside the SPARCS-Project.

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CEN will install a solar-power-plant, supplying a maximum power of 40kWp. For increasing the flexibility in power-usage, a bulk battery will be implemented, and a load-management software will be installed for steering the power streams efficiently. Near Hall 18 there is a parking space equipped with an electrical charging column, used by a local carsharing company that will be enhanced by 2 charging stations that are bidirectional ready and another bidirectional charging station. In Hall 14, the heat generation infrastructure will be digitally networked to achieve automated coupling of demand and consumption.

Table 42 Leipzig - Baumwollspinnerei district data

Position	Value	Unit	Year
Demo size	2 Buildings, Hall 14 and Hall 18	number	2020
Electrical energy demand	689	MWh	2020
Heat demand	1.282	MWh	2020

Intervention L1

Intelligent EV charging and storage

In Intervention L1 CEN will develop, demonstrate, and implement the bi-directional charging. In addition, CEN will analyse the effects of e-mobility for micro grid stabilisation by integration of the e-mobility platform and its integrated charging optimization based on a load management software.

Now, there are just charging stations on-site, which are used by private organisations because this excludes the access to relevant performance-data and there is no historical baseline-data related to E-Mobility at the Baumwollspinnerei. Since bidirectional charging will be monitored together with an EV BMWi3, the KPIs will also picture data which is specific for bidirectional charging currents. When the car is used as a temporary battery, this includes a Peak Load reduction in electrical demand covered by the off-site grid, as well as monetary incentives to the car owner, when electricity is fed out of the car. Electrical grid related KPIs, such as the average interruption duration or frequency, will parallelly monitor the effectivity of the digitized Load Management. Since mobility is a very subjective experience, the numeric data will be supplemented by a survey, in which users can give their feedback on the concept.

Table 43 Leipzig - L1 intervention data

KPIs	Data	Value	Unit	Reference Year -

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				Comments
Energy Storage type	Type	Electrical Storage	-	2020
Energy Storage number of equipment Increase	Storage number	0	#	2020
Energy Storage capacity Increase	kWh	0	kWh	2020
Peak Load Reduction Reduced System Average Interruption Duration Index (SAIDI)	Peak demand	381	kW	2020
Reduced System Average Interruption Frequency Index (SAIFI)	System Average Interruption Duration	n/a	min	No baseline data
Demand from all EV mobility modes; impact on the grid	A sum of the demand from all EV mobility modes Considering EV Smart chargers (Sum of peak demand of all charging stations)	0	kW	2020
User satisfaction of minimum charging level in EVs	User Satisfaction of minimum charging levels in EVs Likert survey results	-	Likert	survey
monetary gains for user (charging costs	EV User charging costs	0	ct/kWh	2020

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vs flexibility revenues)				
satisfaction of minimum charging level for commercial EVs (for carrying out their daily routes)	EV flexibility revenues for the user	0	ct/kWh	2020
Accuracy of Generation forecasting	Predicted generation compared to the actual generation	0	%	2020
Accuracy of storage utilization	The storage utilization predicted compared to the actual utilization of the storage	0	%	2020
Increase in shared EVs availability	#EVs available for sharing	0	%	2020
increase of integrated smart EV charging units	# of smart EV charging stations	0	#	2020
Increased level of utilization of EV charging stations	# of smart EV charging stations	0	#	2020
EV charging potential on-site	Sum of energy charged	0	kWh	2020

Intervention L2

Micro grid inside the public grid

Intervention L2 tackles the challenges of on-site electrical energy production. Specifically, the installation and efficient integration of a 40 kWp PV-power-plant with storage in addition to the existing CHP-capacities. So, the central KPIs cover the self-consumption rate and the resulting development of the energy costs in production and consumption.

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The concept will centrally be supported by a digitized load management solution for information and optimization purposes.
The technical framework of this intervention consists firstly of the aforementioned system of PV-Plant and the according electricity storage. This part will be monitored in terms of increasing the energy production on site, which was appr. 300 MWh in 2020. Secondly smart meters and intelligent sensors will be installed to ensure the necessary granularity and depth in information, as well as to ensure the proper user-demand oriented control of electricity flows. Furthermore, the interface to the public grid will be equipped with a data exchange device in cooperation with LSW. This will enable the balancing of the public and the on-site-demand against each other by a peer2peer-energy-trading-platform.

Table 44 Leipzig - L2 intervention data

KPIs	Data	Value	Unit	Reference Year - Comments
District self-consumption rate	Total district energy demand	1.972	MWh	2020
	Total district Energy Production	301	MWh	2020
	Total Demand Electricity	689	MWh	2020
Reduction of the energy production cost;	Total energy production cost	20	ct/kWh	2020
Reduction of the customer energy cost	Energy cost for the customer	22	ct/kWh	2020

Intervention L3

Heating demand control

Intervention L3 is related to the heating infrastructure on-site. Potentials in efficiency shall be accessed by combining automation, user information and system transparency. It is planned to install smart thermostats in building 14 which can be programmed by the tenant via app. The anonymized user data will be merged with meter data and then converted into a user information cockpit which the tenant will receive via the CENERO energy management tool cenero.one. Through this transparency approach it is expected

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that tenants will be sustainably more aware of their influence on energy demand. Modern automation technique on the other side, will supplement the concept by additionally shutting down electricity consuming components within passive segments of the heating distribution network, if an assignable tenant doesn't request heating. This information, fed into the thermostats, will be communicated by LoRaWAN-signals and processed by actuators steering central valves and pumps in the heating grid. By reducing the energy demand on the tenant's side and decreasing the run time of electrical consumers in the grid the heating system will work more efficiently.

To monitor the over-all performance of the concept, the consumed energy amount is set as the main baseline. The total energy demand of the buildings H14 and H18 was about 1.972 MWh 2020. During the progress of the monitoring phase, this KPI will increasingly be affected by the capability of the smart thermostats to indirectly learn about the characteristics of their surrounding and adapt the heating process properly. So, heat storage capacities of the buildings are implicitly included in the KPI energy demand reduction.

Table 45 Leipzig - L3 intervention data

KPIs	Data	Value	Unit	Reference Year - Comments
Total energy demand reduction	Total energy demand	1.972	MWh	2020
	Total Demand Electricity	689	MWh	2020
	Total Demand Heating	1.282	MWh	2020
Onsite energy ratio OER	Energy production using RES	301	MWh	2020
	Total energy demand	1.972	MWh	2020
Peak Load Reduction	Peak demand (MW)	n/a	kW	-

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4.2 Leipzig West

4.2.1 District details and data available

The Duncker district is located in Leipzig West, in proximity to the Spinnerei block. Right next to the Lindenauer Hafen, which is an outstanding urban renewal program, that brings new life to a vestige harbour in Leipzig West, it is a melting-pot district with a stock of historic buildings. The district encompasses 31 buildings with a living space of 65.000 m2 and includes multiple units, which are priced for social housing needs. With its active and involved tenants, the district is the ideal testing ground for the proposed user-centric control, via a dedicated platform that promotes active involvement of citizens, to optimize the flow of energy.

Within the district, there are seven buildings with 300 apartments owned by Leipziger Wohnungs- und Baugesellschaft mbH (LWB), which are supplied by district heating. These buildings will be our prototype area. All apartments will be equipped with net (smart) metering technology for thermal energy. Within the district, a novel solution for optimising thermal energy consumption through the implementation of human-centric thermal demand response programs (implicit demand response) operated by WSL will be demonstrated. Important for social housing is the optimisation of the utilities. For this reason, WSL will implement a dynamic thermal heating controller, which optimizes the heat production based on information regarding the real thermal need of the building (demand-centric).

In addition, the heat generation of the solar plant will be examined and compared (by LSW) to the heat consumption of the prototype buildings in a sequential manner relative to the potential for different tariffs from a district heating supplier.

The aim of this task is to properly configure and deploy an innovative solution for optimising thermal energy consumption through the implementation of innovative human-centric thermal demand response programmes (implicit demand response) in selected residential building blocks operated by WSL. These housing blocks include social housing flats, which are available to low- or no-income tenants. The optimisation of dynamic consumption as a cost-saving measure is of particular interest in social housing blocks.

The long-term goal is to configure and deploy an innovative solution for optimising thermal energy consumption through innovative human-centric thermal demand response programs.

Intervention L4

Personalized Informative Billing

From the buildings that will participate in activities of this district, one of them has 27 apartments that will be used as the testbed for the applications that will be developed as part of this intervention. For the needs of this intervention, 100 smart heat cost allocators are installed on all radiators of the apartments, allowing for smart thermostat simulation

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and room temperature readings every 15 minutes. In addition, smart meters per apartment will also allow to get the electricity consumption values every 15 minutes.

Under these conditions, the target of this intervention is to engage users towards energy saving actions, by utilizing appropriate applications that offer to the users an overview of alternative energy prices and thermal energy tariff schemes that will allow for understanding their willingness to alter their consumption behaviour. In addition, with the utilization of appropriate normative comparison mechanisms users will be able to position themselves against best-performing peers and, thus, better quantify their energy bill savings potential. Lastly, in this intervention, the connectivity of buildings and their integration in the Virtual Positive Energy Community will be verified, combined with a feasibility study for replication of Mieterstrom model and the demonstration of decentralised energy storage within building blocks for optimized self-consumption of locally produced energy.

To capture the impact of those actions, both the total thermal demand of the district as well as thermal demand of the apartments under consideration need to be considered. Based on the available historical data, the district thermal demand is around 1411MWh, which is equal to thermal energy imported to the district, indicating that the entire thermal energy is at the moment imported in the district, offering a baseline before the implementation of the intervention actions. For the 27 apartments under consideration, the total demand for eating to be used as a baseline is 77.9 MWh.

In the table below, all KPIs defined in T2.1 are presented, accompanied with the needed datasets to calculate them and their respective baseline values. For the datasets that the creation of a baseline value was not possible due to the lack of available data, a per case comment is providing further details about their appropriate handling.

Table 46 Leipzig - L4 intervention data

KPIs	Data	Value	Unit	Reference Year - Comments
Decrease of thermal energy import share in the district	District thermal Energy import (MWh)	1411	MWh	2020
	Total District thermal Energy Demand (MWh)	1411	MWh	2020
Total thermal energy demand reduction	Total Demand Heating (MWh)	1411	MWh	2020
District self-consumption rate	Total District thermal Energy Demand (MWh)	1411	MWh	2020

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	Total district Energy Production (MWh)	0	MWh	2020
	Total Demand Electricity (MWh)	473,6	MWh	2020
Peak Load Reduction	Peak demand (MWh)	n/a	MWh	-

Intervention L5

Human-Centric Energy Management and Control Decision

Utilizing the same testbed as described in intervention L4, the implementation activities of this intervention are focusing on defining detailed and accurate comfort profiles, in order to be able to identify context-aware thermal demand flexibility profiles. To achieve this target, parameters such as the energy behaviour patterns, the comfort preferences and the indoor quality constraints need to be monitored and considered. Utilizing the flexibility profiles, targeted guidance on control actions that will be performed manually, for shedding or shifting the operation of thermal loads within buildings and air quality info through user-interface will be provided as part of the SPARCS Application functionalities.

To capture the impact of those actions, the total thermal demand of the apartments is considered, that based on the available historical data is around 78 MWh. Monitoring the peak load to identify the reduction achieved, combined with the flexibility made available in total, as well as the increase percentage compare of the normal load are also in focus to assess the impact of this intervention.

In the table below, the relevant KPIs, with the needed datasets to calculate them and their respective baseline values are provided. For the datasets that the creation of a baseline value was not possible due to the lack of available data, a per case comment is providing further details about their appropriate handling.

Table 47 Leipzig - L5 intervention data

KPIs	Data	Value	Unit	Reference Year - Comments
Total thermal energy demand reduction	Total Demand Heating (MWh)	77,9	MWh	2020
Peak Load Reduction	Peak demand (MWh)	n/a	MWh	No baseline data currently
Flexibility increase (%) of normal load.	Flexibility % of normal load Buildings/Prosumers	n/a	%	No baseline

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				data currently
Total flexibility available Increase (KW)	Total flexibility available (KW) Buildings/Prosumers"	n/a	KW	No baseline data currently

Intervention L6

Decarbonisation of district heating

The Subtask 4.2.1 "Carbon-free district heating in "Leipzig West" is designed to increase the share of RES in the central district heating system. The RES integration focuses on the planning, construction, and integration in the central district heating system of a solar thermal plant, which should supply the residents in the district with low CO2 heating.

The next step leading to CO2-neutrality is to research how this post-fossil future would look like.

The area "Leipzig West" will be used to create a blueprint for other districts depending on the specifics of each district (e.g., technologies)

L6-1 Demonstration of integration of RES in the central district heating network. Based on the integration of Solar Thermal Energy to District Heating - specifically located in "Lausen" in Leipzig West.

Table 48 Leipzig - L6 intervention data

KPI's	Data	Value	Unit	Reference Year - Comments
Share of RES increase (heat solar thermal)	Average Total Energy Production (Heat)	Approx. 1.500.000	MWh/year	2019 Average, currently produced amount of heat for the entire district heating grid (yearly)
	Energy Production using RES (heat)	0	MWh/year	2019 Currently no RES heat production (in district heating)
CO2-emission reduction through RES heat increase	Amount of saved CO2-Equivalents	n/a	Kg or tons	See above

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Intervention L7

Heat storage (P2H)

In combination with the newly built cogeneration plant "Heizkraftwerk Leipzig Süd" a large, 2-zone hot water storage tank with approx. 50.000 m3 water volume and approx. 1.800 MWh storage capacity (in Winter) is being built for the district heating grid. Planned operation start is in the autumn of 2022 with the start of the heating period. The new heat store will increase the flexibility of cogeneration plants within the district heating grid and serve as a store for excess renewable heat as well. Because the heat storage is located roughly 9 km away from the solar thermal plant (as described in L6 above) it's not possible to provide the exact amount of solar excess heat that is being transferred to the heat store. As an alternative the below mentioned data can provide an indication of the usefulness of the heat storage for the overall grid.

Table 49 Leipzig - L7 intervention data

KPI's	Data	Value	Unit	Reference Year - Comments
Heat Storage Utilization	Average Charge Level	-	°C	Temperature in top layer or every 3 meters; average values monthly or yearly
	Heat Input	-	MW (°C x m3/h) or MWh	Temperature & Volume Flow of water in & out of heat storage is logged and can be provided as power (hourly) or work (daily/monthly/yearly)
	Heat Output	-	MW (°C x m3/h) or MWh	Temperature & Volume Flow of water in & out of heat storage is logged and can be provided as power (hourly) or work (daily/monthly/yearly)

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Intervention L8

ICT integration

Linking of the existing and newly constructed heat storage solutions with the demand side will allow for more efficient controlling of the district heating network. Due to the removal of the power-to-heat plant from intervention L7, based on the changes introduced with the amendment, it was proposed to combine L7 and L8. Therefore, both interventions are treated as one, which is why the table above has been copied here.

Table 50 Leipzig - L8 intervention data

KPI's	Data	Value	Unit	Reference Year - Comments
Heat Storage Utilization	Average Charge Level	n/a	°C	Temperature in top layer or every 3 meters; average values monthly or yearly
	Heat Input	n/a	MW (°C x m3/h) or MWh	Temperature & Volume Flow of water in & out of heat storage is logged and can be provided as power (hourly) or work (daily/monthly/yearly)
	Heat Output	n/a	MW (°C x m3/h) or MWh	Temperature & Volume Flow of water in & out of heat storage is logged and can be provided as power (hourly) or work (daily/monthly/yearly)

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4.3 Virtual Positive Energy Community

4.3.1 Virtual Positive Energy Community details and data available

The Virtual Positive Energy Community represents the creation of a future regenerative energy system based on the orchestration of consumers, producers, and energy storage capabilities in virtually connected environments and systems. The Virtual positive energy community is coordinated by a digital platform ecosystem for the entire city of Leipzig. The goal of this ecosystem is the optimization of energy generation and consumption through integration, analysis and control of assets and devices. This is done by the utilization of intelligent methods to match demand and supply side. Doing so, ecosystem aims to solve the energy trilemma by finding the equilibrium between economic profitability, system reliability, and ecological sustainability.

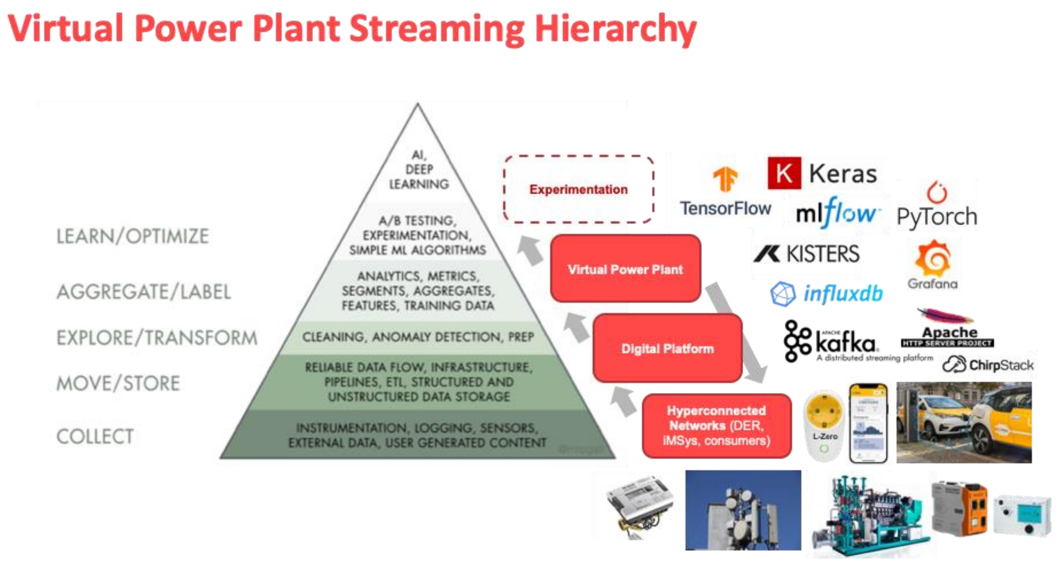

Figure 6 Leipzig - VPP Streaming Hierarchy

Intervention L9

Implementation and installation of an open standard based ICT platform that we call the "L-Box".

This intervention serves as a foundational platform for multiple assets from further related interventions. L9 covers the interaction and integration between energy generating, storing and consuming entities into a virtual connected community. To achieve this level of integration and control, an ICT ecosystem including a virtual power plant is developed and implemented. The core of the virtual power plant consists of PV panels that generate 1412 MWh annually, 1 - 3000 dynamic consumers with an estimated 210kW of flexible loads that are available within seconds and the "Konsumzentrale" building with a total energy consumption of 274 MWh. These entities are aggregated on the digital platform and optimized with respect to ecological and economical restrictions and goals. As an end-point of the optimization a half a dozen block heating power plants

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serve as flexible and controllable loads that are shifted based on the outcome of the VPP optimization.

Table 51 Leipzig - L9 intervention data

KPIs	Data	Value	Unit	Reference Year - Comments
Share of RES increase	Total Energy Production	Electricity: 1.412,76 (WSL PV) /// Heat: Konsumzentrale: 105,210	MWh	2019 WSL housing blocks, PV plants Overall production and RES production is the same.
	Energy production using RES	1.412,76 (WSL PV)	MWh	
District self consumption rate	Total district energy demand	Heat demand Konsumzentrale: 262,462	MWh	2019 Demand: WSL and Konsumzentrale
	Total district Energy Production	790,13 (26 PV systems WSL production selfconsumption) with 68,79 (selfconsumption)	MWh	2019
	Total Demand Electricity	168,59 (demand consumer WSL / LWB by selfconsumption) /// Konsumzentrale: 105,210	MWh	2019 Electricity only

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Total flexibility available Increase	Total flexibility available	0	KW	2019 Smart plugs will provide that data, but at the moment is 0
Flexibility increase (%) of normal load.	Flexibility % of normal load	0	%	2019 Smart plugs will provide that data, but at the moment is 0
Flexibility provided	Flexibility provided	0	KWh	2019 Smart plugs will provide that data, but at the moment is 0
# of demand requests	demand requests	0	number	2019 Smart plugs will provide that data, but at the moment is 0
renumeration due to flexibility delivered (Euro)	renumeration due to flexibility delivered Buildings/Prosumers, EV smart chargers, escalators/elevators	0	Euro	2019 Incentive totals, bonus points
Onsite energy ratio OER	Energy production using RES	1.412,76 (WSL PV)	MWh	Covered from values above
	Total energy demand	Heat demand Konsumzentrale: 262,462 Electricity demand 168,59 (demand consumer WSL / LWB		

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		by selfconsumption) /// Konsumzentrale: 105,210		
Fossil fuels Energy Generation decrease	Fossil fuels Energy Generation	0	MW	No fossil generation
Increase of integrated systems share (smart control/ VPP/ storage)	Total available (RES, storage, etc)	57 PV (WSL)	number	2019
# of smart equipment	Smart meters for electricity and heating available	0	number	2019
# of smart equipment	Smart sensors for temperature, humidity, illuminance	0	number	2019
# of smart equipment	Smart actuators	0	number	2019
# of digital platforms used	digital platforms used	0	number	2019
Energy Storage type	Type	n/a	type	-
Energy Storage number of equipment Increase	Storage number	n/a	number	-

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Intervention L10

Economically reasonable integration of open and standardized Sensors and Systems

L10 describes the sensor and metering transmission infrastructure based on the LoRaWAN standard that has been successfully established throughout the entire city of Leipzig. This intervention covers no energy consuming or generating assets.

Table 52 Leipzig - L10 intervention data

KPIs	Data	Value	Unit	Reference Year - Comments
# of smart equipment	# of smart equipment	0	Smart meters for electricity and heating available (#)	2019
		0	Smart sensors for temperature, humidity, illuminance (#)	2019
		0	Smart actuators (#)	2019
# of digital platforms used	# of digital platforms used	0	# of digital platforms used	2019
number of piloted solutions	number of piloted solutions	0	number of piloted solutions utilizing this technology	2019

Intervention L11

Establishment of a distributed cloud-centric ICT System which enables an intelligent energy management system.

Intervention L11 covers the development, implementation and distribution of green plugs for the L-Zero initiative. These devices provide the gateway to the instantly available flexible loads (estimated 210kW) of the 1 - 3000 dynamic consumers. The smart plugs are used to regulate the grid so that mains load peaks can be smoothed. The smart plugs have the advantage that they can be controlled externally or by the user. The advantages of the customer are the transparency of their energy consumption and, if necessary, a monetary

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saving, the reduction of electricity consumption. The reduced power consumption reduces CO2 emissions.
Additionally, L11 also represents the integration of 10MW of a 15MW "storage farm" operated by BMW (the vehicle company). The production site in Leipzig provides data for the virtual integration (simulation) of this battery storage into the virtual power plant.

Table 53 Leipzig - L11 intervention data

KPIs	Data	Value	Unit	Reference Year - Comments
number of smart devices (green plug)	number of smart devices (green plug)	0	number of devices	2019
number of inquiries about green plug	number of inquiries about green plug	0	number of inquiries	2019

Intervention L12

Implementation of a human-centric interface/application

Another part of the Leipzig Virtual Energy Community is the testbed of 27 apartments in Leipzig West, as presented in interventions L4 and L5. With the utilization of the application and the special focus on electricity consumption improvements in that case, the users will be offered the capability to monitor and control their individual energy consumption, gaining a better understanding of the impact of everyday activities and behaviour on the building energy performance status.
Also in this intervention, in order to prepare the baseline for accurate impact assessment verification during the monitoring phase of the project, the total thermal and electricity demand of the apartments are considered. Based on the available historical data the total demand for heating is around 78 MWh, while the electricity demand is estimated at approximately 40MWh. The overall Peak Load reduction, combined with the reduction of the energy demand, energy costs and CO2 emissions reduced per apartment, are also in focus in this intervention.
In the table below, all KPIs and related datasets are presented.

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Table 54 Leipzig - L12 intervention data

KPIs	Data	Value	Unit	Reference Year - Comments
Total energy demand reduction	Total Demand Heating (MWh)	77,9	MWh	2020
	Total Demand Electricity (MWh)	40,5	MWh	Expected demand
Reduction of the energy demand per apartment	Reduction of the total energy demand of each apartment	n/a	MWh	No baseline data
	Reduction of CO2 emissions per apartment	n/a	MWh	No baseline data
	Reduction of the customer's energy costs per apartment	n/a	MWh	No baseline data
Peak Load Reduction	Peak demand (MWh)	n/a	MWh	No baseline data

Intervention L13

Visual metaphors and constructs/ dashboards for energy footprint analysis

Complementing the activities of intervention L12, this intervention utilizes the same environment to demonstrate the creation of Energy Behavioural Profiles, allowing through the utilization of the application for self-evaluation and normative comparisons of energy behavioural patterns. Via comparison of normalized energy performance information against peer top-performing consumers with similar characteristics, energy savings, cost savings and CO2 emission reduction are the main the targets.

With the same targets as in L12, identical KPIs and baselining data are defined and presented in the table below.

Table 55 Leipzig - L13 intervention data

KPIs	Data	Value	Unit	Reference Year - Comments
	Total Demand Heating (MWh)	77,9	MWh	2020

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Total energy demand reduction	Total Demand Electricity (MWh)	40.5	MWh	Expected demand
Reduction of the energy demand per apartment	Reduction of the total energy demand of each apartment	n/a	MWh	No baseline data
	Reduction of CO2 emissions per apartment	n/a	MWh	No baseline data
	Reduction of the customer's energy costs per apartment	n/a	MWh	No baseline data
Peak Load Reduction	Peak demand (MWh)	n/a	MWh	No baseline data

Intervention L14

Commissioning on specific energy savings targets

Concluding the functionalities of the application as described in interventions L12 and L13, target of this intervention if the maximise energy savings at the community level, by triggering individual consumers to achieve specific energy savings over specific timeframes. With the utilization of a Social Engagement Loop, further engagement and involvement of consumers in energy saving actions is established.

Sharing identical KPIs with L12 and L13, the datasets needed and the corresponding baselining data defined and presented in the table below.

Table 56 Leipzig - L14 intervention data

KPIs	Data	Value	Unit	Reference Year - Comments
Total energy demand reduction	Total Demand Heating (MWh)	77,9	MWh	2020
	Total Demand Electricity (MWh)	40,5	MWh	Expected demand
Reduction of the energy demand per apartment	Reduction of the total energy demand of each apartment	n/a	MWh	No baseline data
	Reduction of CO2 emissions per apartment	n/a	MWh	No baseline data

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	Reduction of the customer's energy costs per apartment	n/a	MWh	No baseline data
Peak Load Reduction	Peak demand (MWh)	n/a	MWh	No baseline data

Intervention L15

Integration of 2G e-bus charging

This intervention transforms the bus lines 89/74/76 from diesel fuel buses to e-buses. Altogether, the company will have 21 e-buses. Furthermore, LVB will modernize the central bus garage at the location "Lindenauer Bushof", also located in Leipzig West. The location will receive a central charging system with about 10 charging points. As the charging process during the operation of the lines (e.g. at the station Connewitzer Kreuz) often occurs during the peak consumption time slots, it challenges the congestion management of the distribution grid. The nightly charging processes at the central home station however occur during times when the consumption pattern exhibits less variances. Accordingly, a load shifting away from the charging during operation in favour of home station charging will ease the grid operation and thus the overall integration of renewable energy assets (that are difficult to forecast and plan) into the virtual power plant.

Table 57 Leipzig - L15 intervention data

KPIs	Data	Actual Data	Unit	Reference Year - Comments
Increase of EVs share in local transportation (%)	Total number of vehicles in local transportation (#)	1090	Number	2019
	Electric vehicles in local transportation (#)	358	Number	2019
increase of integrated smart EV charging units	# of smart EV charging stations	34 stations	Number	2020
Increased level of utilization of EV charging stations	∑kWh charged	0,9	GWh	2020

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Intervention L16

Load-balanced fleet management

This intervention demonstrates load-balanced fleet management and charging based upon user specific inputs to the platform defining their flexibility. The system should provide the opportunity to reserve specific charge points in advance based upon suitable predefined and dynamic charging tariffs. This includes the positioning of additional charging points (38 before project start, amounting to 85000 kWh) on the city surface. Additionally, LSW integrates 50 fleet-based electric vehicles in an instantly available load-shifting program.

Table 58 Leipzig - L16 intervention data

KPIs	Data	Actual Data	Unit	Reference Year - Comments
increase of integrated smart EV charging units	# of smart EV charging stations	19 stations (38 points)	Number	2019
Increased level of utilization of EV charging stations	∑kWh charged	0,9	GWh	2019

Intervention L17

Conceptualization and application of a public Blockchain for transactions between energy consumers, producers, service providers and grid system operators in a microgrid

Through a feasibility study, the role of blockchain in local market dynamics will be examined, combining generation plants, consumer's demand, and methods on how meter point operation and meter data management can be approached more efficiently and cost effectively. More specifically, this intervention represent the Ethereum based p2p network that is used to simulate the trade of small amounts of surplus energy within the virtual power plant. Shifted loads, as also presented in the KPI tables of L9, can be found below.

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Table 59 Leipzig - L17 intervention data

KPIs	Data	Value	Unit	Reference Year - Comments
Total flexibility available Increase	Total flexibility available	0	KW	2019 Smart plugs will provide that data, but at the moment is 0
Flexibility increase (%) of normal load.	Flexibility % of normal load	0	%	2019 Smart plugs will provide that data, but at the moment is 0
Flexibility provided	Flexibility provided	0	KWh	2019 Smart plugs will provide that data, but at the moment is 0
# of demand requests	demand requests	0	number	2019 Smart plugs will provide that data, but at the moment is 0
renumeration due to flexibility delivered (Euro)	renumeration due to flexibility delivered Buildings/Prosumers, EV smart chargers, escalators/elevators	0	Euro	2019 Incentive totals, bonus points

Intervention L18

Integration of the planned "community energy storage" (CES) and "community demand response" (CDR)

The virtual energy community consists of a defined number of households in Leipzig. The electricity demand of these customers is balanced by LSW against a set of real and/or

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virtual assets. The individual customers are able to change the electricity consumption in response to external signals. ULEI analyses the consumer behaviour. Based on ex-post electricity demand, the optimal scheduling of the community energy storage is determined. The economic performance and optimal size are compared to the actual scheduling. LSW will provide ULEI with all necessary data and will give feedback and hints for the further development of the prediction model. The analyses are primarily based on the metering infrastructure of LSW. The relevant KPI of this intervention is closely related to L9 and L11.

Table 60 Leipzig - L18 intervention data

KPIs	Data	Value	Unit	Comments
Increase of integrated systems share	Green sockets available	0	#	2021 Roll-out not started
Electricity demand reduction	Electricity demand	1500	MWh	Expected demand for 1000 flats
Peak Load Reduction	Peak demand (MWh)	n/a	MWh	Will be provided after roll-out and data analysis
Flexibility increase (%) of normal load.	Flexibility % of normal load Buildings/Prosumers	n/a	%	Will be provided after roll-out and data analysis
Total flexibility available Increase (KW)	Total flexibility available (KW) Buildings/Prosumers"	n/a	KW	Will be provided after roll-out and data analysis

4.4 Macro Level

The actions grouped as macro level interventions in Leipzig aim at making more data available for integrated climate just energetic district planning. To facilitate municipal planning, all available district energy data shall in the future be stored centrally on an urban data platform. To gain experience with this process, data available from the SPARCS districts will be uploaded as a demo, and experiences will be analysed.

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This will in the future hopefully allow the municipality to better handle data itself and perform some of its analysis and planning tasks itself, instead of commissioning certain analyses externally.

Additionally, to extend positive energy districts, the technical requirements of buildings, blocks and districts to be part will be summarized in a checklist.

Furthermore, citizen engagement activities such as workshops, information days, postcard placements and other things are being carried out to sensitize citizens for climate friendly behaviour, include them where possible in ongoing planning, and make possible for them to be part of the positive energy community.

4.4.1 Intervention details and data available

The planning of energy positive communities builds upon the learnings from already implemented actions. It is set to integrate planning tools of the City of Leipzig (Urban Data Platform) with data and knowledge gathered during the implementation of the positive energy community, experiences from energetic district refurbishment programmes and elaboration with specific city units. Furthermore, it determines the requirements to expand and integrate more buildings and stakeholders into the positive energy community.

The City of Leipzig is currently developing an operational concept for the implementation of the urban data platform of the city which is based on the already existing geospatial data infrastructure. In this project, the City of Leipzig already works closely with its public utilities, especially Leipziger Stadtwerke (LSW). Action 19-1 is a use case for the urban data platform to explore the added value of urban data for the municipality and other stakeholders. Additionally, the City of Leipzig is working on setting up a digital twin for the city. The integration of energy and building data from the SPARCS demo districts will contribute to the overall goal of creating a profound information and knowledge base for urban development and planning decisions.

Intervention L19

Energy Positive District Planning

L19 shall integrate energy and building data from e.g. SPARCS demo districts into the Urban Data Platform of the City of Leipzig, in order to allow for advanced and integrated district and building planning. For this, energy and building data during the implementation phase of the energy positive community will be monitored and collected. The city of Leipzig will determine the requirements for integrating data into the urban data platform (data formats, API's, etc.), and possible use cases. As a preparation, two workshops (M18, M20) were conducted on requirements for climate and building data as well as direct contact established with responsible city administration units, namely the Office for Housing Subsidies and Urban Renewal and the Office for Geoinformation. With the help of these workshops, one possible use case could be identified: data gathered within one SPARCS district (Duncker district) shall be used for analysing the framework

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conditions and the preparation of a district-related energy and CO_2 balance sheets. SPARCS data will be combined with existing city data e.g. on building level, traffic and greenery. It will be assessed how the combined provision of data to the different city departments involved in climate just district planning will allow a more profound and well-orchestrated planning approach.

Table 61 Leipzig - L19 Intervention Data

KPIs	Data	Value	Unit	Comments
Professional stakeholder involvement	How much have professional stakeholders outside the project team been involved in planning and execution?	n/a	Scale from 1 to 5, where 1 is the lowest value	No baseline data
How SPARCS supports, facilitates, accelerates city plans	How much has the project benefited from, contributed to and follows the strategic documents of the city?	n/a	Scale from 1 to 5, where 1 is the lowest value	No baseline data
Data availability	Number of energy and building datasets integrated in the Urban Data Platform	0	number	2018

Intervention L20

Standard model for smart cities

In L20, the city of Leipzig will identify and describe requirements for buildings and stakeholders to be integrated into the positive energy community. The city of Leipzig will determine next steps to integrate energy-related building data into the Urban Data Platform (UDP), and develop a checklist/action guideline for integrating energy-related building and district data into the urban data platform based on the experiences from L191 o. Actions carried out under T4.2, T4.3 and T4.4, and findings and recommendations derived from their implementation will be carefully reviewed to determine technical requirements for further integration of relevant energy-related building data.

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Table 62 Leipzig - L20 Intervention data

KPIs	Data	Value	Unit	Comments
Number of check lists with relevance to the topic	Check lists available	0	number	2018
Leadership	How much is the leadership of the project successful in creating support for the project?	n/a	Scale from 1 to 5, where 1 is the lowest value	No baseline data

Intervention L21

Community empowerment support activities through dialogues, transferring ownership, knowledge-transfer etc.

Most of the participatory activities undertaken in Leipzig demo district aimed to engage the Wohnen & Service Leipzig (WSL) tenants and have been introduced to the local community along with the technical partner's achieved milestones. Until 23.02.2022 five citizen engagement (CE) actions were rolled-out and covered three out of four levels of planned participation depth in Dunkerviertel: informing, sensitizing, and engaging. Due to COVID-19 restrictions only two of them were analogue – the rest was undertaken in a so-called contact-free way where people could still engage in the SPARCs co-creation and experience exchange process despite tight pandemic restrictions. In addition to the activities within the demo district, complimentary measures were undertaken i.e. citywide workshop organized during the event "Days for Environment" (Ger. Umwelttage) and numerous media threads (local newspaper, Leipzig SPARCs website).

Based on revision of each CE action a fourfold rise in the awareness of the SPACRs innovations and technical solution could be observed. Based on this estimation as well as direct exchange with the local community/feedback from the Dunckerviertel tenant assistant, the undertaken measures proved to be effective in terms of informing and engaging the local community into the co-creation process of energy positive district. Until now the most appealing technical product was MeineLWB-App as it directly helps tenant to have a better overview on their energy consumption and parallel serves as a good starting point for more complex tools like SPARCs app. MeineLWB-App was accepted well by the community and prove to cover four lenses of innovation (desirability, feasibility, viability, and sustainability).

During the participation process an additional need for assistance from the municipality-based NGO Mosaik emerged. The NGO is responsible for engaging the Arabic- and Kurdu-speaking tenants who newly moved to Germany and need guidance on the energy use. A district wide action that offers citizen science workshops on SPARCs topics to school

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students will be introduced this year, the delay was unfortunately caused by a severe COVID-19 situation in Saxony in Autumn-Winter 2021.

Table 63 Leipzig – L21 Intervention data

Characteristics of the city of Leipzig	Category	Value	Unit	Comments
How many experiments information and co-creation activities were conducted?	Citizen engagement	6 (30.07.2021-18.02.2022)		2021
% of people are aware of the existing solutions before and after interventions	Citizen engagement	Before: 5-7 After: 20	%	2022 Dunkerviertel
Did you feel that you were able to affect and participate in the ideation of future directions?	Citizen engagement	4	Scale from 1 to 5, where 1 is the lowest value	2021
How well does the business model(s) cover the four lenses of innovation (desirability, feasibility, viability and sustainability)?	Citizen engagement	MeineLWB App: 4	Scale from 1 to 5, where 1 is the lowest value	2021 (no empirical data, conclusion based on discussion with Dunkerviertel community during the CE activities)
# of co-creation sessions for positive energy districts	Citizen engagement	n/a		Educational offer for school students was already set, due to COVID-

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				19 and numerous restrictions concerning schools it was not possible to be undertaken.
Citizens' co-ownership of energy utilities	Citizen engagement	0		2021 In Dunkerviertel
Inclusion of hard-to-reach groups in energy transition	Citizen engagement	n/a		Refugees and asylum seekers, Planned, over 20 apartments to engage

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5 CONCLUSIONS

With the overall goal of SPARCS being to demonstrate and validate the technical and socio-economic viability, and impacts, of scalable, innovative solutions for planning, deploying and rolling out smart and integrated energy systems, the need to carefully monitor and assess the impact achieved is crucial.

In this deliverable, an Ex-ante evaluation of the lighthouse demos introduced in SPARCs is performed, allowing a better understanding of the status before the deployment of the actual solutions and interventions of the project. A point of reference for all indicators under consideration is defined, complemented with valuable contextual and business-oriented information to be used in business planning activities.

Using a bottom-up approach, an analysis of the Espoo and Leipzig lighthouse cities is performed, that is to be used as a reference for the project impact and replication potential assessment. Moreover, the Ex-Ante analysis investigates additional aspects in the lighthouse demos, such as local infrastructure characteristics, the stakeholders involved in the activities and the status of energy, mobility and ICT set-ups, in order to deliver a holistic view of the current situation and provide valuable feedback to the demo WPs (WP3-WP4), as well as, to the exploitation planning activities of the project (WP7).

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